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

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April 24, 2015

Preliminary version

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 not driven by differential attrition among teachers entering during recessions.

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 and conference participants at 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, Christian Dustmann, Bernd Fitzenberger, Joshua Goodman, Anna Gumpert, Eric A. Hanushek, Lawrence Katz, Asim Khwaja, Amanda Pallais, 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.

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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 this argument. A first strand of the literature has used regional variation in relative teacher salaries to assess how pay is related to teachers' academic quality (e.g., Figlio, 1997). However, salaries may be endogenous to teacher quality. A second strand has used changes in the labor market over time – in particular, the expansion of job opportunities for women – to estimate how the academic quality of new teachers varies with job market alternatives (e.g., Bacolod, 2007). A key limitation of both strands of research is that the available measures of academic quality are poor predictors of teacher effectiveness (cf. Jackson et al., 2014). This important policy question therefore remains unresolved.

To answer this question, we exploit business cycle conditions at career start as a source of exogenous variation in the outside labor-market options of potential teachers. 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 common and well-validated measure of teacher effectiveness (Chetty et al., 2014a). Combining our novel identification strategy with VAMs of individual elementary school teachers from one 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 almost 33,000 fourth- and fifth-grade teachers in Florida's public 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 2000-1 through 2008-9 school years. The data also contain information on teachers' total experience in teaching (including experience in other states), which is used to compute the year of entering 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. Dummy variables for each teacher provide estimates of each teacher's value-added to student test scores. 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 10% SD more effective in raising math test scores than teachers who entered the profession during non-recessionary periods. The effect is one third as large for reading value-added. Quantile regressions indicate that the difference between recession and non-recession entrants in math VAMs 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 $14,000 per classroom taught each year.[1] Under the more realistic assumption that only 10% of recession-cohort teachers are pushed into teaching because of the recession, these teachers are roughly one SD more effective than the teachers they push out.

Our results are not driven by differential attrition of recession and non-recession cohorts. Although teachers entering during recessions are more likely to exit the profession, the attrition pattern we find works against our finding and suggests that our main results understate the differences in effectiveness between recession and non-recession cohorts at career start. Placebo regressions show that what is driving the result is the business cycle condition at career start, not at some specific age or at any other point before or after teachers' career starts. 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

[1]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.

driven by differences in teacher race, gender, age at career start, cohort sizes, and school characteristics. Our finding that the effect of recessions on teacher effectiveness is twice as strong in math as it is 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 is a reasonable assumption 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.[2]

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 this 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 broader job market has improved (National Public Radio, 2015).

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

[2]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 has changed substantially (e.g., New York Times, 2010). This last downturn does not drive our results, however, since our sample is dominated by teachers from earlier cohorts.

Goldhaber and Walch (2013) may be attributable to the 2008-09 financial crisis, rather than an authentic reversal of long-term trends.

We are the first to show that recessions have a causal effect on entering teachers' effectiveness in raising student test scores. Previous research has called attention to the potential importance of outside job options for teacher quality. Bacolod (2007) documents a decrease of average academic quality (as measured by standardized test scores and undergraduate institution selectivity) among 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 direct measures of teachers' performance on the job.[3] To our knowledge, ours is the first paper that uses VAMs based on statewide administrative data when measuring selection into teaching. While previous work has relied on easily observed teacher characteristics such as SAT or ACT scores that are at best weakly correlated with actual effectiveness, VAMs directly measure teachers' ability to improve student performance.

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.[4] 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. Hence, 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, describes our value-added measures, and presents our empirical model. Section 4 reports results on the relationship between business cycle conditions and teacher effectiveness in math and

[3]In a similar fashion, Loeb and Page (2000) link regional variation in relative teacher wages and unemployment rates to student attainment. Their study lacks a direct measure of teacher quality, however. See also Corcoran et al. (2004); Hoxby and Leigh (2004) and Lakdawalla (2006) on the importance of outside labor-market options for the supply of teachers in the US.

[4]A small literature also studies the wage effects of graduating from college during a recession (e.g., Kahn, 2010; Oreopoulos et al., 2012).

reading, provides robustness checks, and discusses the results. Section 5 provides potential implications for policymakers. Section 6 concludes.

2 A Simple Model of Occupational Choice

To motivate our anaylsis, we present a simple Roy-style model of self-selection (Roy, 1951) where individuals choose an occupation to maximize earnings.[5] Specifically, individuals can choose between working in the teaching sector (t) and working in the business sector (b), which represents all labor market outside options of potential teachers. Individual earnings depend on average earnings in the respective sector, $\mu_{t,b}$, 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 $w_{t,b}$ are earnings in the teaching and business sector, respectively; v is the (uni-dimensional)[6] ability of the individual, distributed with mean zero and standard deviation σ_v^2; and η_t denotes the relative returns to skills in teaching versus business. If the same skills are valued in business and teaching, but teaching has lower returns to skills, then $\eta_t \in (0, 1)$.[7] If there are no returns to skills in teaching, then $\eta_t = 0$; if returns to skills are negatively correlated across sectors, then $\eta_t < 0$.

The recession term s 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). The model thus allows for a recession impact on earnings in the teaching profession, but only assumes that it is stronger in the business sector. Empirically, employment in the teaching

[5] 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.

[6] Since our model only uses one dimension of ability, we implicitly assume that the two abilites typically used in Roy models are positively correlated. Exisiting research suggests this is reasonable. For example, Chingos and West (2012) examine the earnings records of more than 130,000 classroom teachers employed by Florida public schools between the 2001–2 and 2006–7 school years, of whom about 35,000 teachers left the classroom during that period. Among teachers leaving for other industries, a 1 standard deviation increase in estimated teacher value-added is associated with 6–8 percent higher earnings outside teaching.

[7] This seems plausible since wages are more compressed in the government-dominated teaching profession than in the business sector (cf. Dolton, 2006).

sector is less cyclical than employment in the business sector (Berman and Pfleeger, 1997; Simpkins et al., 2012).

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 relative earnings of teachers have increased compared to more cyclical outside options:

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

Average teacher ability increases because individuals with higher ability prefer working in the teacher profession; formally, $\frac{\partial v_{marg}}{\partial s} = \frac{1}{(1-\eta_t)} > 0$.[8] We expect to find this in the empirical analysis, as the underlying assumptions (that $\eta_t \in (0,1)$ and teaching is a relatively stable occupation) have strong empirical support. If $\eta_t > 1$ or $\eta_t < 0$, we would expect negative effects of recessions on teacher quality.

We empirically analyze the importance of labor market outside options for teacher quality. In our model, changes in labor market opportunities are modelled as changes in relative 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 we take this model seriously, however, our estimates shed light on the discussion whether increasing teacher pay increases teacher quality.

While our simple model only addresses the supply of teachers, fluctuations in demand might also explain changes in teacher quality over the business cycle. Fluctuations in demand can explain higher quality of teachers during recessions if the following two conditions hold.

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

First, school authorities are able to assess the quality of applicants and accordingly hire the more able ones. Second, the number of hired teachers is smaller during recessions than during booms. If one of these two conditions does not hold, fluctuations in demand cannot explain why recession teachers are more effective than non-recession teachers.[9]

3 Setup, Data, and Empirical Strategy

First, we briefly describe 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

Like almost every state, Florida requires teachers to have both earned a bachelor's degree and taken a certain number of courses in the field of education in order to receive a teaching license.[10] To become a teacher in Florida, applicants need at least a temporary teaching certificate. This certificate is awarded to applicants with either be a Bachelor's degree plus a certification by the state of Florida or a federal institution, or the applicant may possess a Bachelor's degree with either (i) a major in the subject matter or (ii) a GPA of 2.5 a required set of subject matter. With a temporary certificate, individuals can teach for three years. At the same time, they can proceed to acquire a professional license through on-the-job training.

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 school years 2000–01 through 2008–09, with each student linked to his or her courses (and corresponding teachers). We

[9]In practice, neither of the two conditions are likely to hold. School authorities are unlikely to identify effective teachers since teacher effectiveness is hardly correlated with observable characteristics except experience (cf. Jackson et al., 2014). Furthermore, employment in the government education sector does not typically decrease during recession (see Figure 1).

[10]The number of required courses for certification is usually around 30 credits in the subject matter and for the specific grade (elementary, middle, or high school) being taught, about the same number that is required for a college major in the subject. School districts, in emergency situations, are able to hire temporary teachers without certification, and teachers may be hired provided they begin a set of courses leading toward what is known as alternative certification (see Chingos and Peterson, 2011).

focus on test 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 beginning in 2002. The data also contain information on the demographic and educational characteristics of each student, including gender, race, free or reduced price lunch eligibility, limited English proficiency status, special education status, and age.

The EDW data also contain detailed information on individual teachers, including their demographic characteristics and 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 contains teachers and their students in each school year based on course enrollment data. The teacher experience variable we construct reflects all years the teacher has spent in the profession, including both public and private schools in Florida and other states. Because the experience variable contains some inconsistencies, we assume the latest observed experience value is correct, and adjust all other values accordingly.[11] 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.

Starting from the baseline dataset that contains all 4th and 5th grade students with current and lagged test scores, we applied several restrictions in order to keep only those teachers who can be confidently associated with students' annual gain in test scores. We only keep student-teacher pairs if the teacher accounts for at least 80% of the student's total instruction time (deleting 24% of students from the baseline dataset). To avoid estimating value-added based on few observations, we exclude the very few classrooms that have fewer than seven observations with current and lagged scores in the relevant subject. We also exclude classrooms with more than 50 students (deleting 2.4% of students) and classrooms where more than 50% of students receive special education (deleting 2% 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 1%). Finally, we drop classrooms for which the teacher's experience is missing (deleting 2.5% of students).

[11] We also adjust for gaps in teaching. Results are qualitatively similar when using the original, uncorrected values.

These restrictions leave us with roughly 33,000 public school teachers with VAMs for math and reading.

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, making the indicator forward-looking in the sense that it captures the economic decline. Accordingly, teachers starting their careers in the 1990-91 school year are classified as having entered during a recession. Additionally, we use alternative business cycle indicators such as unemployment (in levels and annual changes; for college graduates, nationwide, and Florida-only; for different industries) and GDP, which come from the BLS and Thomson Reuters, respectively. NBER's recession indicator is highly correlated with unemployment rates (in both levels and differences) and per capita GDP at career start.

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 estimate the causal effect 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, limited English proficiency, and special-education status. Classroom controls include all student characteristics aggregated to the class level and class size. School-level controls include the school-specific shares of students who are black, white, Hispanic, and free-lunch eligible, enrollment, as well as urbanicity indicators of the school location.

To obtain an estimate of each teacher's value-added, we add a dummy variable, θ_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; π_{gt} are grade-by-year fixed effects[12]; and ϵ_{ijgst} is the error term with mean zero.[13] After estimating the teacher VAMs, θ_j, we standardize them separately for math and reading to have a mean of zero and a standard deviation of one.

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 of 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 (while Equation (3.3) is based on 4th- and 5th-grade students as this requires only one lag of test scores).[14]

[12] 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.

[13] To simplify notation, we drop the subscripts j, g, and s for the lagged test score and for the student-, classroom-, teacher-, and school-level characteristics.

[14] If teacher effectiveness varies a lot across schools, then much of the variation would be eliminated by including school fixed effects. Therefore, we do not include school fixed effects in our main model, but rather include school characteristics. For robustness, in alternative VAMs, we additionally include school fixed effects and school-by-year fixed effects, respectively.

Although widely used by researchers, the reliability of value-added models of teacher effectiveness using non-experimental data continues to be debated (see, e.g., Chetty et al., 2014a; Rothstein, 2014). The key issue is non-random matching of students and teachers both across and within schools, which would bias estimated teacher effectiveness if there were unobserved differences across students that are not accounted for by the control variables included in the model.

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 classrooms within the same school were randomly assigned to teachers (Kane and Staiger, 2008). Similarly, Chetty et al. (2014a) exploit quasi-random variation of teachers switching schools, providing evidence that VAMs do reflect causal impacts of teachers. Even if our VAMs were biased by non-random matching of students and teachers, it is unclear whether and in what direction the non-random matching would bias our estimates of the relationship between recessions and teacher effectiveness.

Finally, critics argue that value-added measures reflect teaching to the test rather than authentic improvements in knowledge. In a seminal article, Chetty et al. (2014b) find that having been assigned to higher value-added teachers increases earnings at age 28 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 (cf. Jackson, 2012). The weight of the evidence, however, indicates that teacher value-added measures do reflect important aspects of teacher quality.

Teacher Value-Added and Business Cycle Conditions at Career Start

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 the teacher's value-added in math and reading. We use business cycle conditions at career start as a source of exogenous variation in the relative economic benefits of teaching. 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 if this was a recessionary period and equals 0 otherwise.[15] The vector X_j includes teacher characteristics. Most importantly, it contains total experience in the teaching profession (fourth-order polynomial), which is not accounted for in the VAM computation but has been shown to influence teacher effectiveness (Papay and Kraft, 2015). As experience differs for recession and non-recession teachers, due in part to the idiosyncratic distance between recessions in our sample period, experience is a necessary control. Additional controls included in some specifications are age at career start, educational degree, gender, race, and school characteristics. Note that these teacher characteristics do not influence the business cycle. The reduced-form estimate γ (with only experience controls) therefore identifies a causal effect. To the extent that the inclusion of additional controls influences the estimate of γ, they would represent mechanisms rather than confounding variables. Because our source of variation is the yearly business cycle condition, we cluster standard errors at the level of the career start year.

Based on the Roy model, we expect to find a positive effect of recessions at career start on teacher effectiveness. We argue that recessions negatively shock the outside options of potential teachers. Following this shock, both the number of applicants 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 may argue that teacher quality 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. If we find a positive effect, this would suggest that intrinsic motivation is a second-order concern relative to the effects of compensation through selection

[15] Aternatively, we use unemployment rates and differences as well as GDP growth.

on ability. Note also that because effectiveness is estimated during the same period (2001-2009) for all teachers, 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 first document significant differences in math and reading effectiveness between recession and non-recession teachers. Using kernel density plots and quantile regressions, we show at which parts of the effectiveness distribution recession and non-recession teachers differ. In placebo regressions, we show that there is no association between teacher effectiveness and business cycle conditions several years before and after career start or 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 and non-recession teachers (Table 1). The average unemployment level of college graduates at career start was higher for teachers who started during recessions. Similarly, unemployment was rising for recession teachers, but falling slightly 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 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. There are substantially more non-recessions teachers than recession teachers. Although all other differences in the groups' observed characteristics are insignificant, recession teachers have on average 8% SD higher math VA and 5% SD higher reading VA than non-recession teachers. Consistently, Figure 2 shows that the relation between (experience-adjusted) value-added in math and the one-year unemployment difference for college graduates is strongly positive.

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 and school 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 baseline specification. The value-added gap increases to 10.3% SD when adding a fourth-order polynomial of teaching experience (Column 2).[16] 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 white or male, also does not affect our coefficient of interest. Similarly, adding important student characteristics at the school level, such as the share of black students and the share of students who are eligible for free or reduced-price lunch, does not explain the value-added difference.[17] The specification with all control variables indicates that recession teachers are 9.3% SD more effective in teaching math than non-recession teachers. Since all control variables (except experience) reflect 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 (e.g., Hanushek et al., 2015), we expect selection effects over the business cycle to be weaker for reading effectiveness than for math effectiveness. As expected, a similar, but weaker pattern arises for teachers' VAM in reading. The bivariate relationship between recession at career start and teacher effectiveness is positive, but insignificant (Column 1 in Table 3). As for math, controlling for teaching experience increases the coefficient on the recession indicator; it also becomes significant at the five percent level (Column 2). Adding the other covariates reduces the coefficient of

[16]Previous work has shown that teacher experience affects teacher value-added non-linearly (e.g., Rockoff, 2004).

[17]Differences in the placement of recession and non-recession cohorts may be mechanisms through which recessions impact productivity (cf. Oyer, 2006).

interest marginally. In terms of magnitude, the recession indicator for reading is half as large as the coefficient for the math VAM (around 5% SD). As we expect selection effects to be stronger among potential teachers with higher skills in math, we focus on teachers' math effectiveness in the remaining analyses.[18]

While Table 2 indicates that recession teachers are on average more effective in teaching math 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 impacts 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 value-added distribution in math for recession cohorts (Figure 3).[19] In quantile regressions that control for a fourth-order polynomial in experience, we analyze this finding further (Figure 4). While very low-performing teachers at the 5th percentile have the same VAM, recession teachers are more effective than non-recession teachers from the 15th percentile of the value-added distribution onwards. The largest difference between the distributions appears among highly effective teachers, with point estimates of differences peaking at almost 20% SD at the 95th percentile. The quantile regressions hence indicate that recession teachers are more effective than non-recession teachers along almost the entire effectiveness distribution, with the largest differences in the upper part of the distribution.

In Table 4, we run our preferred specification on subsamples to assess differential impacts across different types of teachers. Male teachers seem to be more affected than female teachers (Columns 1 and 2). This is consistent with the career options of men being more strongly influenced by recessions than are those of women.[20] 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

[18]Since we analyze teachers' effectiveness only for math below, we will sometimes refer to teacher effectiveness without explicitly adding "math." 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.

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

[20]This finding might also reflect greater measurement error in the career start year for females, who are more likely to have interrupted their careers due to childbearing. While we adjust our experience variables for gaps in teaching during our sample period, we do not observe gaps prior to 2001.

indirect evidence that minorities are more impacted by recessions than non-minorities in the business sector. Finally, in columns (7) and (8), we find that teachers starting their teaching careers at an above-median age 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. Overall, the pattern of results across subsamples provides additional evidence of the importance of outside options for teacher quality.

4.2 Placebo Analyses

Since macroeconomic conditions are indicated by the NBER recession indicator, we assume that it is the business cycle condition immediately before career start that matters for occupational choice. 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 and after our estimated 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 business cycle conditions in the years before and after our preferred date are all close to zero and statistically insignificant.[21]

One might worry that our career start year measure is capturing the effect of macroeconomic conditions at key ages (Giuliano and Spilimbergo, 2014). For example, individuals might 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 recession indicators at ages 18-32 (two-year steps) to test whether it is the economic conditions just before starting a teacher career that determine teaching quality. As before, coefficients on the recession indicators at various ages are close to zero, and statistically insignificant (Column 4).

These findings strongly support our hypothesis that it is the economic conditions immediately before career start that change the selection into teaching and affect teacher quality.

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

4.3 Further Robustness Checks

We also evaluate the robustness of our results using alternative measures of teachers' outside options. In Table 6, we run our baseline specification using our preferred NBER recession indicator (Column 1), GDP growth (2), the unemployment level (3), and one-year unemployment differences (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. Consistent with the baseline 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 one percent level. In brackets we report the implied magnitude of the recession effect on teacher value-added based on the mean difference in each business cycle indicator between recession and non-recession cohorts. This reveals that the coefficient estimates for the alternative measures imply somewhat weaker, but qualitatively similar effects.[22] It is unlikely that the alternative job opportunities of potential teachers are evenly distributed across industries. For example, one would expect only few potential teachers to work in agriculture. In columns (5) and (6), we find that the unemployment situation 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 a selection of potential teachers into the occupation who would have alternatively chosen industries requiring similar skills.[23] Overall, the results using alternative business cycle measures strongly support our main finding.

We use national rather than Florida-specific unemployment rates in this analysis because state-level unemployment rates are not available for BA holders, the former are more reliable, and the mobility of teachers across states is relatively high. For instance, in our sample, 19% of teachers have some experience outside of Florida. Hence, using Florida-specific economic shocks should underestimate the true effect. When using Florida-specific unemployment

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

[23] A similar pattern emerges if we use unemployment levels instead of unemployment differences. Results for other industries (not reported) reveal that, relative to the unemployment difference of college graduates, unemployment rates in the construction and mining sector and in financial services are less strongly related to teacher value-added, while unemployment rates in wholesale and retail industries are similarly related.

measures (not shown; results available on request), effects are similar to those reported in Table 6, but somewhat weaker.

Since the number of recessions in our sample is limited, one might worry that the result is driven by only one or two recessions. To address this issue, we include a separate binary indicator for each recession (Table 7).[24] Column 1 indicates that teachers in almost all recessions (except in recession years 1981–83, 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 1981, 1982, and 1983 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 lasting positive effects on value-added. The recession impact is not driven by any single recession.

To assess the sensitivity of our results with respect to the value-added measure, we run our preferred specification with alternative TVA measures (Table 8). Column (1) presents the results for our preferred TVA measure. In column (2), we add school fixed effects when estimating the value-added measures. The inclusion of school fixed effects eliminates any bias from unobserved school characteristics that influence teacher effectiveness, but will also remove variation in true teacher effectiveness to the extent that teacher quality varies systematically across schools. The gap in effectiveness between recession and non-recession teachers is somewhat attenuated, but the change in the estimates is statistically insignificant. In column (3), we add school-year fixed effects when estimating TVA, likely further removing 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 our standard teacher value-added measures are computed with differing precision. Our results are unaffected by weighting our baseline regression by the number of student-year or teacher-year observations that underlie our quality measure.

Additional regressions (not shown) indicate that the results are also robust to the inclusion of other control variables and to using different sample restrictions. Results are unaffected,

[24]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 these very small cohorts.

for example, by directly controlling for the number of years a teacher appears in our dataset. Similarly, cohort size is not related to either teacher math effectiveness or to business cycle conditions.[25]

4.4 Differential Attrition of Teachers

We find that teachers starting their careers in recessions are more effective math teachers. On the one hand, quality 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 2001, 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 8, which shows that recession effects are generally increasing over time. 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).[26] Controlling for teachers' value-added, we find that recession teachers are in fact more likely to drop out. This is to be expected as recession cohorts are likely more extrinsically motivated than non-recession teachers. Controlling for recession status at career start, more effective teachers are also less likely to drop out. Because our definition of attrition includes retiring teachers, in Column (3)we exclude those born before 1950; this does not change our results.

[25]When regressing cohort size on career start year and career start year squared, the binary indicator for recession cohort teachers is insignificant.

[26]Because the school year 2009 is the attrition target year, all specifications in Table 9 exclude teachers who started teaching in 2009 since these teachers could not drop out yet and hence provide no information.

Among the sample of teachers who started teaching during our sample period (about 47% of the full sample), recession teachers are also more likely to leave than non-recession teachers. More importantly, in recession cohorts, exiting teachers are more effective compared to exiting non-recession teachers. This pattern works against our result, suggesting that the TVA gap is even larger at career start and decreases over time. This is confirmed in Column 4 when we directly look at TVA, finding a large TVA gap at career start which decreases with increasing experience. Taking these estimates at face value, this implies that the TVA gap closes after around 17 years. However, note that we do not observe the attrition pattern before 2001 directly, making this interpretation somewhat speculative.

Finally, we directly control for attrition behavior in our main analysis. As before, teachers who dropped out by 2009 tend to have lower value-added measures than teacher who stay in teaching. Importantly, controlling for attrition does not change the relationship between recession at career start and math effectiveness (Columns 5 and 6).

In sum, differential attrition between recession and non-recession teachers does not explain our main finding. Although teachers entering during recessions are more likely to leave the profession, this attrition reduces the estimated difference in effectiveness between recession and non-recession teachers. This suggests that our main results, which compare teachers across all experience levels, understate the differences 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 principle be driven by demand or supply fluctuations over the business cycle (or both). 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 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 measures. This is corroborated by official statistics from the BLS which indicate that employment in the local government education sector typically does not decrease during recessions (with the exception of the recessions in 1981-1983 and the great recession; see Figure 1 and Berman and Pfleeger, 1997).

Furthermore, 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 TVA (e.g., Chingos and Peterson, 2011; Jackson et al., 2014). Apart from the fact that both conditions required for demand fluctuations to generate our findings are unlikely to hold, our quantile regression results show that the strongest effect is observed at the upper end of the TVA distribution. This suggests that increases in high-quality supply rather than decreases in demand for low-quality teachers are at work.[27]

In sum, increases in the supply of high-quality applicants during recessions seem to drive our results. Teacher cohorts seem to 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 push out, 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 quality difference would be equal to our reduced-form estimate (0.1 SD). However, if only 10% of the recession teachers (roughly the difference in the shares of recession and non-recession teachers with a Master's or PhD degree) went into teaching due to the recession, the difference in effectiveness would be 10 times as large, around one standard deviation.

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. Hence, the results suggest that policymakers may be able to hire better teachers if they increased

[27]Business cycles should also have no other treatment 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 TVA (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 impact on individual's productivity in teaching. The reduced-form estimate still represents a causal effect.

teacher pay. The question, however, is whether this is efficient. Chetty et al. (2014b) find that students taught by a teacher with a 1 SD higher value-added measure at age 12 earn on average 1.3% more at age 28. Using this figure, our baseline recession effect translates into differences in discounted lifetime earnings between recession and non-recession teachers of around $14,000 per classroom taught each school year (evaluated at the average classroom size in our sample). This is equivalent to more than 20% of the average teacher salary in Florida ($46,583 in school year 2012-2013 according to the Florida Department of Education).

Do these private benefits exceed the public costs that are associated with an increase in teacher pay needed 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). Since the general unemployment rate at career start differs by two percentage points between recession and non-recession teacher cohorts in our sample, this translates into 4%–12% earnings differences between recession and non-recession teachers. 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 the pay of entering teachers and thereby improve average teacher effectiveness.

Magnitudes aside, our findings suggest that policymakers may 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, less effective, individuals into the teaching profession. If intrinsic motivation was correlated with effectiveness, recession teachers would on average be less effective than non-recession teachers. Since we find the opposite, intrinsic motivation seems to be a second-order concern, and thus increasing teacher pay likely helps to attract 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.

6 Conclusion

We are the first to provide causal evidence on the importance of outside labor market options for teacher quality. Our identification strategy exploits business cycle conditions at career start as a source of exogenous variation in potential teachers' alternative job opportunities. We combine this novel strategy with a direct and well-validated measure of teacher effectiveness, value-added to student math and reading test scores. Our reduced-form estimates show that teachers who entered the profession during recessions have significantly higher math and reading value-added measures than teachers who entered the profession during non-recessionary periods. This finding is best explained by a Roy model in which more able individuals prefer teaching over other professions during recessions due to lower (expected) earnings in the alternative occupations. While the setting differs, 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). Our results have important implications for policymakers. Recessions may serve as a window of opportunity for recruitment in the public sector.

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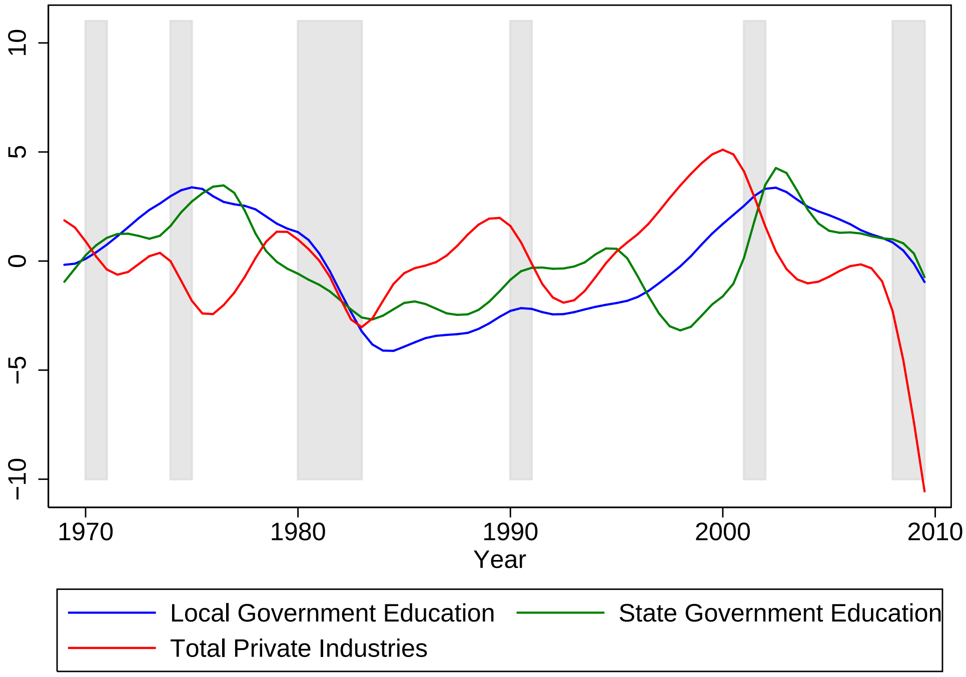
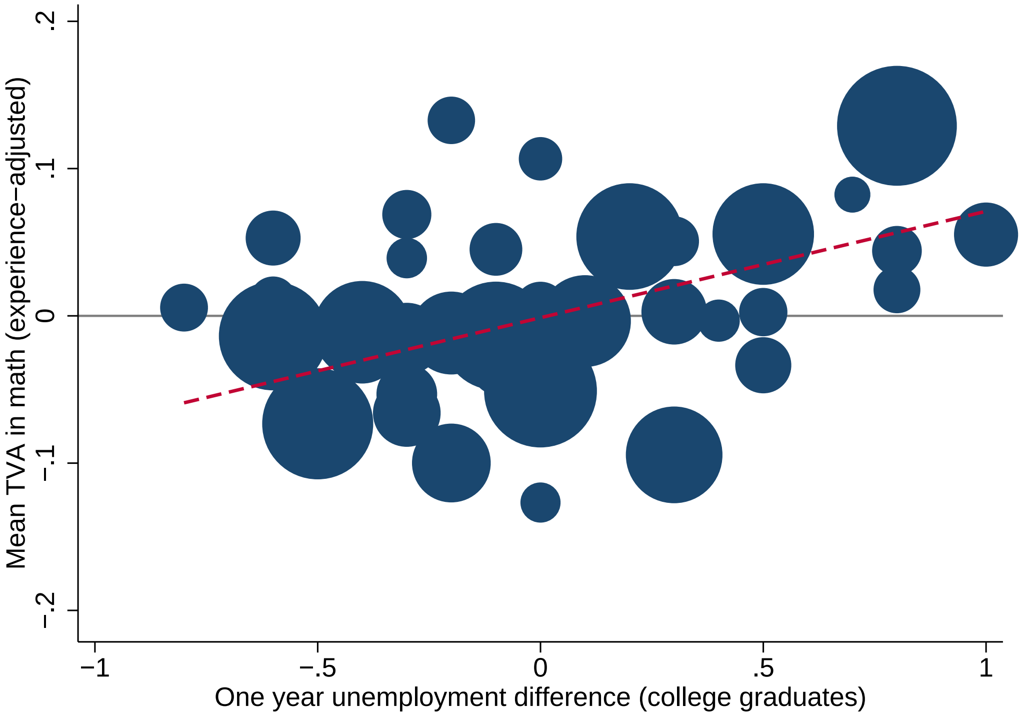
Figures and Tables

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



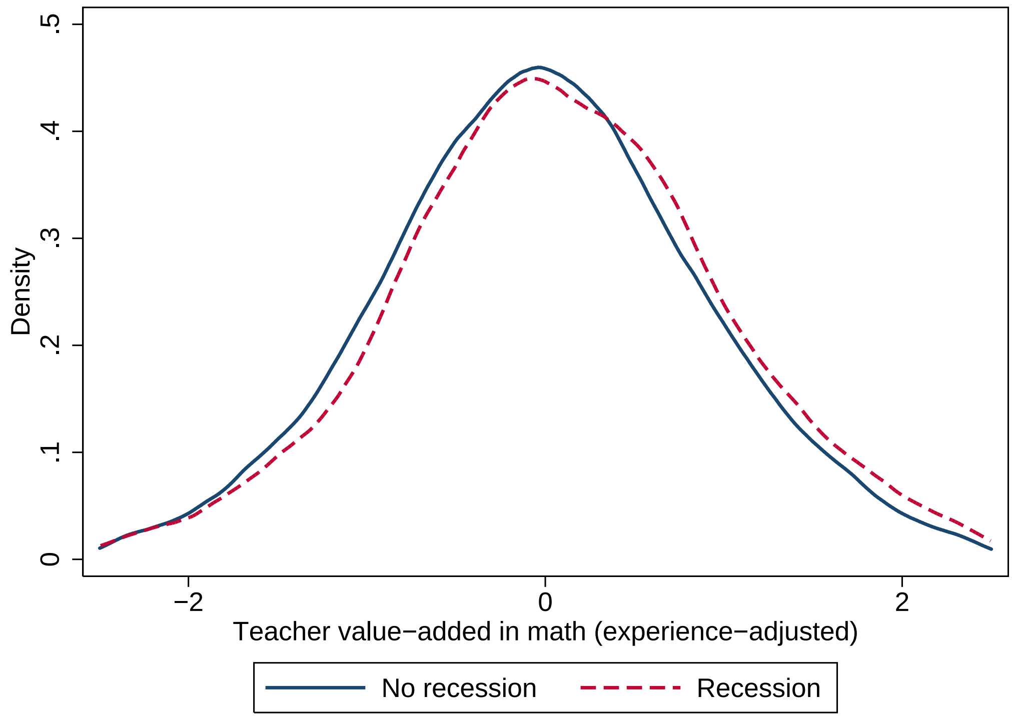
Notes: Data come from the Current Employment Statistics (Establishment Survey) of the US Bureau of Labor Statistics. Number of employees in the indicated sector are seasonally adjusted. Semiannual frequency; indexed to 100 in second half of 2007, and subsequently detrended. Shaded areas: Recessions as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

Figure 2: Mean Teacher Math Effectiveness (Experience-adjusted) and One-Year Unemployment Difference



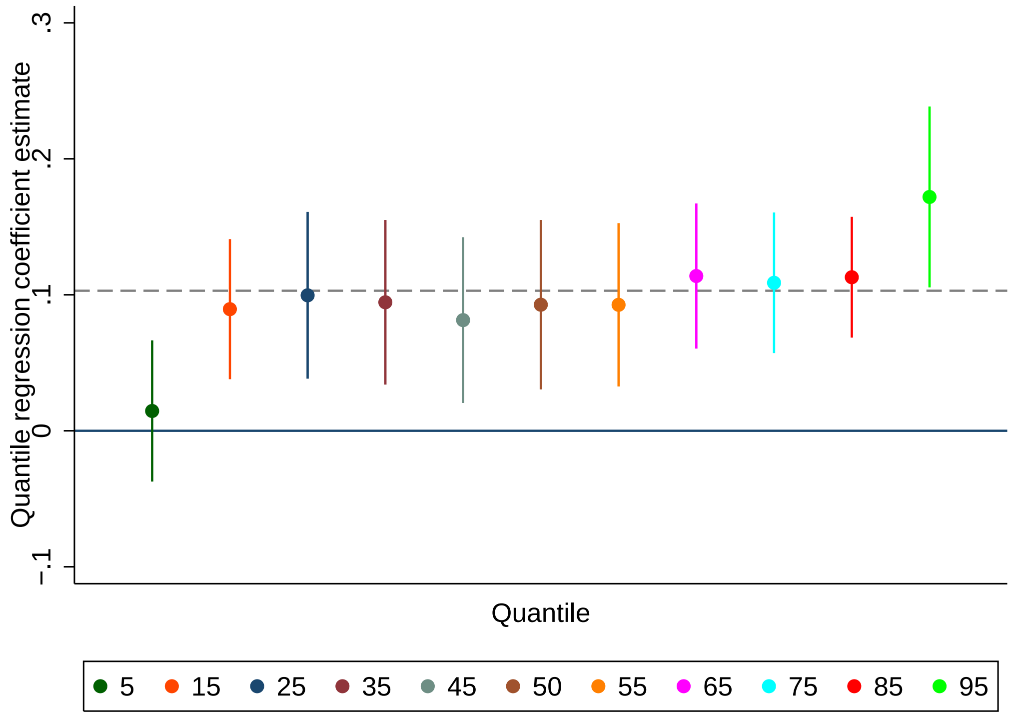
Notes: Cohort means of teacher value-added (controlling for a fourth-order polynomial in experience) in math and one-year unemployment difference for college graduates. Unemployment rates come from the BLS. 2008-09 excluded as outlier.

Figure 3: Recession at Career Start and Teacher Math Effectiveness (Kernel Density Estimates)



Notes: Kernel density estimates of TVA in math (controlling for a fourth-order polynomial in experience), by recession cohort status. Excludes teachers with adjusted $|TVA| > 2.5$ for better visibility (826 of 32,900 obs.). Value-added measure normalized to have mean 0 and standard deviation 1 for all teachers.

Figure 4: Recession at Career Start and Teacher Math Effectiveness (Quantile Regressions)



Notes: Coefficients (and 95% confidence bounds) from separate quantile regressions of teacher value-added measure in math on NBER recession indicator in year before career start at different quantiles, controlling for fourth-order polynomial of experience. Dashed grey line: OLS estimate. Standard errors are clustered at the career start year level.

Table 1: Summary Statistics by Recession Status at Career Start

	Recession			Non-recession			Difference
	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	p-Value
Unemp. (college)	2.93	0.55	5176	2.24	0.46	27414	0.00
Unemp. diff. (college)	0.91	0.47	5176	-0.12	0.33	27255	0.00
Male	0.12	0.32	5188	0.13	0.33	27946	0.46
Master's or PhD	0.41	0.49	5188	0.38	0.48	27946	0.28
White	0.71	0.45	5188	0.76	0.43	27946	0.39
Black	0.15	0.36	5188	0.14	0.35	27946	0.15
Hispanic	0.12	0.33	5188	0.09	0.29	27946	0.48
Experience	11.06	10.95	5188	8.67	9.44	27946	0.62
Career Start	1993.98	11.41	5188	1996.97	10.17	27946	0.54
Age at career start	31.26	7.90	5188	31.47	8.24	27946	0.79
Year of birth	1962.72	12.35	5188	1965.50	11.88	27946	0.51
% black (School)	0.25	0.26	5188	0.24	0.25	27946	0.55
% free/red. lunch (School)	0.57	0.25	5188	0.55	0.24	27946	0.44
TVA (math)	0.07	1.02	5172	-0.01	1.00	27769	0.05
TVA (reading)	0.04	1.02	5188	-0.01	1.00	27946	0.45

Notes: Descriptive statistics of data set. Business cycle measures at estimated career start, recession in year before career start. Recession indicator is taken from NBER business cycle dates. Standard errors are clustered at the career start year level.

Table 2: Recession at Career Start and Teacher Math Effectiveness

	Dependent variable: TVA in math				
	(1)	(2)	(3)	(4)	(5)
Recession	0.081**	0.103***	0.094***	0.089***	0.093***
	(0.040)	(0.022)	(0.015)	(0.013)	(0.014)
Experience		0.092***	0.068***	0.066***	0.066***
		(0.014)	(0.017)	(0.017)	(0.017)
Experience^2		-0.007***	-0.007***	-0.007***	-0.007***
		(0.001)	(0.001)	(0.001)	(0.001)
Experience^3		0.000***	0.000***	0.000***	0.000***
		(0.000)	(0.000)	(0.000)	(0.000)
Experience^4		-0.000***	-0.000***	-0.000***	-0.000***
		(0.000)	(0.000)	(0.000)	(0.000)
Year of birth			-0.019***	-0.018***	-0.018***
			(0.006)	(0.006)	(0.006)
Age at career start			-0.025***	-0.024***	-0.023***
			(0.006)	(0.006)	(0.006)
Master's or PhD				0.069***	0.069***
				(0.010)	(0.010)
Male				-0.036**	-0.030*
				(0.018)	(0.017)
White				-0.051*	-0.060**
				(0.027)	(0.027)
% black (School)					0.249***
					(0.039)
% free/red. lunch (School)					-0.331***
					(0.046)
Clusters (Career start years)	60	60	60	60	60
Obs. (Teachers)	32941	32941	32941	32941	32941
R^2	0.001	0.016	0.019	0.021	0.026

Notes: Regressions of teacher value-added measure in math on NBER recession indicator in year before career start. Standard errors in parentheses clustered 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: TVA in reading				
	(1)	(2)	(3)	(4)	(5)
Recession	0.048	0.052**	0.044**	0.041**	0.047**
	(0.064)	(0.023)	(0.017)	(0.016)	(0.018)
Experience		0.084***	0.068***	0.066***	0.062***
		(0.011)	(0.015)	(0.015)	(0.015)
Experience^2		-0.006***	-0.006***	-0.006***	-0.006***
		(0.001)	(0.001)	(0.001)	(0.001)
Experience^3		0.000***	0.000***	0.000***	0.000***
		(0.000)	(0.000)	(0.000)	(0.000)
Experience^4		-0.000***	-0.000***	-0.000***	-0.000***
		(0.000)	(0.000)	(0.000)	(0.000)
Year of birth			-0.014**	-0.013**	-0.014**
			(0.006)	(0.006)	(0.006)
Age at career start			-0.016**	-0.015**	-0.015**
			(0.006)	(0.006)	(0.006)
Master's or PhD				0.039***	0.037***
				(0.013)	(0.013)
Male				-0.139***	-0.124***
				(0.018)	(0.019)
White				-0.024	-0.068***
				(0.020)	(0.020)
% black (School)					0.235***
					(0.036)
% free/red. lunch (School)					-0.535***
					(0.037)
Clusters (Career start years)	60	60	60	60	60
Obs. (Teachers)	33134	33134	33134	33134	33134
R^2	0.000	0.022	0.023	0.026	0.037

Notes: Regressions of teacher value-added measure in reading on NBER recession indicator in year before career start. Standard errors in parentheses clustered 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: TVA in math							
Subsample:	Male	Female	Master's/PhD	Bachelor's	White	Non-White	$\leq$ Median Age at Career Start	>Median Age at Career Start
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Recession	0.165***	0.094***	0.097***	0.099***	0.068***	0.161***	0.077***	0.131***
	(0.046)	(0.019)	(0.030)	(0.018)	(0.015)	(0.040)	(0.019)	(0.036)
Clusters (Career start years)	54	60	58	58	58	58	60	45
Obs. (Teachers)	4171	28770	12596	20345	24681	8260	17535	15406
R^2	0.018	0.016	0.007	0.020	0.023	0.011	0.016	0.017

Notes: Coefficients from separate regressions of teacher value-added in math on NBER recession indicator in year before career start in different subsamples, controlling for fourth-order polynomial in experience. Standard errors in parentheses clustered 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: TVA in math			
Recession at:	(1)	(2)	(3)	(4)
Preferred year	0.103***	0.110***	0.090***	0.105***
	(0.022)	(0.023)	(0.018)	(0.023)
Preferred year -1 yr.		0.022		
		(0.030)		
Preferred year -2 yrs.		0.014		
		(0.016)		
Preferred year -3 yrs.		0.026		
		(0.022)		
Preferred year +1 yr.			0.022	
			(0.024)	
Preferred year +2 yrs.			-0.026	
			(0.017)	
Preferred year +3 yrs.			-0.036	
			(0.022)	
Age 18				-0.008
				(0.015)
Age 20				0.003
				(0.018)
Age 22				-0.015
				(0.012)
Age 24				-0.016
				(0.015)
Age 26				-0.019
				(0.015)
Age 28				-0.021
				(0.016)
Age 30				-0.021
				(0.017)
Age 32				0.020
				(0.018)
Clusters (Career start years)	60	60	60	60
Obs. (Teachers)	32941	32941	32941	30038
R^2	0.016	0.016	0.017	0.014

Notes: Regressions of teacher value-added measure in mathematics on NBER recession indicator at different points in time. Preferred year refers to timing used in all other regressions. Control is fourth-order polynomial in experience, standard errors in parentheses clustered at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%

Table 6: Recession at Career Start and Teacher Math Effectiveness (Alternative Business Cycle Measures)

	Dependent variable: TVA in math					
	(1)	(2)	(3)	(4)	(5)	(6)
Recession	0.103***					
	(0.022)					
	[0.103]					
GDP growth		-0.012**				
		(0.005)				
		[-0.020]				
Unemp. (College)			0.047***			
			(0.017)			
			[0.033]			
Unemp. diff. (College)				0.065***		
				(0.016)		
				[0.066]		
Unemp. diff. nonagric. ind.					0.028***	
					(0.009)	
					[0.057]	
Unemp. diff. agric. ind.						0.006
						(0.009)
						[0.013]
Clusters (Career start years)	60	59	40	39	57	57
Obs. (Teachers)	32941	32417	32402	32244	32936	32936
R^2	0.016	0.015	0.016	0.017	0.016	0.015

Notes: Coefficients from separate regressions of teacher value-added in math on alternative business cycle measures in career start year (recession indicator is one-year lag). Unemployment rates for college refer to BLS unemployment data of college graduates (4 years and above until 1991, degree holders after 1991) and are only available starting 1970. All unemployment rates are from the BLS. Control is fourth-order polynomial in experience. Standard errors in parentheses clustered at the career start year level. Brackets report effects taking into account mean differences between recession and non-recession teachers (recession effects). Significance levels: *** p< 1%, ** p< 5%, * p< 10%

Table 7: Recession at Career Start and Teacher Math Effectiveness (Single Recessions)

	Dependent variable: TVA in math		
Recession year (career start)	(1)	(2)	(3)
1970	0.099***	0.098***	0.072*
	(0.027)	(0.027)	(0.040)
1974	-0.000	-0.001	-0.004
	(0.021)	(0.021)	(0.024)
1980	0.001	-0.015	-0.009
	(0.016)	(0.019)	(0.024)
1981	-0.007		
	(0.016)		
1982	-0.041**		
	(0.016)		
1990	0.093***	0.093***	0.099***
	(0.011)	(0.011)	(0.018)
2001	0.115***	0.115***	0.103***
	(0.010)	(0.010)	(0.017)
2008	0.256***	0.256***	0.223***
	(0.026)	(0.026)	(0.039)
Career start years:	all	all	+/- 2 years around Recessions
Clusters (Career start years)	48	48	28
Obs. (Teachers)	32857	32857	19113
R^2	0.011	0.011	0.015

Notes: Regressions of teacher value-added measure in mathematics on startyear fixed effects when NBER recession indicator is equal to one (recession cohorts). Excludes observations with a startyear before 1962 (Cohorts with less than 20 teacher obs.; mean cohort size is 1,292). In column two, recession cohorts of recession of 1981 and 1982 are combined. Control is fourth-order polynomial in experience, standard errors in parentheses clustered 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 TVA Measures)

	Dependent variable: Various TVA measures (math)				
	(1)	(2)	(3)	(4)	(5)
Recession	0.103***	0.088***	0.060***	0.107***	0.097***
	(0.022)	(0.027)	(0.014)	(0.032)	(0.030)
Fixed Effects (TVA)	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	0.016	0.012	0.012	0.014	0.014

Notes: Coefficients from separate regressions of different teacher value-added measures (with and without fixed effects, experience dummies, and analytical weights) in math on NBER recession indicator in year before career start, controlling for a fourth-order polynomial in experience. Value-added measures differ with respect to usage of fixed effects, experience dummies and use of weights as indicated in table. Standard errors in parentheses clustered 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)	(3)	TVA in math (4)	(5)	(6)
Recession	0.058**	0.130***	0.066**	0.194***	0.084***	0.175***
	(0.024)	(0.036)	(0.029)	(0.048)	(0.022)	(0.038)
TVA (math)	-0.026***	-0.039***	-0.025***			
	(0.005)	(0.010)	(0.006)			
Recession*TVA	0.002	0.030**	0.000			
	(0.012)	(0.010)	(0.016)			
Recession*Experience				-0.019*		
				(0.011)		
Recession*Experience^2				0.0005		
				(0.0003)		
Dropout					-0.137***	-0.069**
					(0.015)	(0.027)
Subsample	Start years		Year of birth	Start years		
	<2009	2001-08	>1950	all	<2009	2001-08
Clusters (Career Start Years)	59	8	49	60	59	8
Obs. (Teachers)	32417	15207	27349	32941	32378	15207
R^2	0.005	0.015	0.005	0.017	0.014	0.028

Notes: Regressions of attrition indicator (columns (1) through (3)) and teacher value-added in math (columns (4) through (6)) on regressors as shown in the table. Attrition defined as no teacher observation in 2009. Career start year 2009 dropped as teachers cannot drop out yet. Control is fourth-order polynomial in experience. Standard errors in parentheses clustered at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%