High School Inputs and Labor Market Outcomes over a Career:
New Data and Estimates from Wisconsin

Craig A. Olson
Visiting Research Associate
Industrial Relations Section
Princeton University

Institute of Labor & Industrial Relations
Department of Economics
University of Illinois-Urbana/Champaign
caolson@illinois.edu

Deena Ackerman
U.S. Department of the Treasury

December 2016

Paper presented at the ASSA and Winter LERA Meetings, Chicago IL, Jan 8, 20117.

This research uses data from the Wisconsin Longitudinal Study (WLS) of the University of Wisconsin-Madison. Since 1991, the WLS has been supported principally by the National Institute on Aging (AG-9775, AG-21079, AG-033285, and AG-041868), with additional support from the Vilas Estate Trust, the National Science Foundation, the Spencer Foundation, and the Graduate School of the University of Wisconsin-Madison. Since 1992, data have been collected by the University of Wisconsin Survey Center. The authors thank Andrea Johnson and Sak-Keong Chang for the many hours of work they spent reading and coding the microfiche reports in the archives of the Wisconsin State Historical Society that were essential for the completion of this study. The authors also thank Bob Hauser and the staff working on the Wisconsin Longitudinal Survey (WLS) for answering numerous questions about the WLS and for providing access to the information needed to match the school district data to the WLS. The views expressed are those of the authors and do not represent the views of U.S. Treasury Department.

Abstract

This study presents new evidence on the relationship between high school inputs measured at the time male respondents attended high school and the earnings of these same individuals throughout their careers, when they were about 35, 52 and 64 years of age. To accomplish this task, we matched newly coded data on the characteristics of Wisconsin high schools in the 1950s to the 1/3 random sample of 1957 Wisconsin high school graduates that are included in the Wisconsin Longitudinal Survey. Our estimates show a significant positive relationship of proxies for teacher human capital (education and experience) on student earnings that remain unchanged at all three career points. Our preferred estimates imply a $1000 difference ($2010) in teacher human capital raises earnings each year by 1.89-2.20 percent. We use our point estimates and a baseline career earnings model for male Wisconsin high school graduates constructed from the 1960-2000 Censuses to estimate the returns to communities from their investments in students. Our preferred estimates show the present value of the benefits to students from investing a $1/student for 12 years falls between $17 and $20 (all 2010 dollars) with an internal rate of return between 18 and 19 percent. We also find high school inputs have a strong effect on the assets of these students in 2004 when they are about 64 years old. We believe these results are the first estimates of the lifetime returns to school quality using individual panel data. Our estimates remain virtually unchanged using a variety of alternative specifications and samples.

A substantial literature on the relationship between elementary and secondary school inputs and student achievement has developed over the last 25 years.[1] This study contributes to this literature by offering new evidence of the effect of high school inputs on career-long earnings using a uniquely rich Wisconsin data set. With this data we explore the effect of high school inputs received by male high school students measured at the districtl level on the earnings of these same individuals when they were about 35, 52 and 65 years of age.[2] To our knowledge, these results are the first estimates from micro-data that match local school inputs to data on the earnings of students throughout their full working lives. The estimates obtained from these data permit us to calculate rates of return to investments in school quality based on estimated treatment effects from more than just the early years of the careers of a sample of students.

In 1957 researchers at the University of Wisconsin–Madison began a study of a one-third random sample of the Wisconsin high school graduating class of 1957, a study that would ultimately continue for over five decades. This study, the Wisconsin Longitudinal Study (WLS), provides detailed information on respondents collected from public records and major surveys administered in 1957, 1964, 1975, 1992–93, 2004 and 2011.[3] The original WLS data provided limited information on the characteristics of the schools that the WLS respondents attended. Therefore, to supplement the WLS, we matched to the records of most respondents who attended public high school information

[1] Card and Krueger (1992) is the classic "recent" study that revived interest in the relationship between school resources and labor market outcomes. An earlier body of literature developed in response to the release of the Coleman Commission report (1966) on discrimination in American schools. This earlier literature is reviewed in Hanushek (1986).

[2] In Olson and Ackerman (2000) we investigated the impact of high school inputs on the earnings of male high graduates when they were in their mid-thirties. We found average district teacher salaries and teacher human capital, including means years of teaching experience and share of teachers with advanced degrees, had a positive impact on the earnings of their students when they were in their mid-thirties.

[3] See Herd et al. (2014) for a history and description of the WLS.

on the characteristics of their school during 1954–57.[4] These data were obtained from annual reports filed by each school district in June of each year with the Wisconsin Department of Public Instruction (WDPI) and archived at the Wisconsin State Historical Society in Madison, Wisconsin. These annual reports provide detailed information at the school district level on expenditures, teacher characteristics, and enrollment.[5] The reports permit the construction of virtually all of the school input measures used in previous research for each of the four years the respondents were in high school. The main analysis in this study offers new evidence of the effect of high school inputs on labor market earnings in each of the three main survey years (1975, 1992-93 and 2004).[6]

To preview our results, our preferred estimates of labor market earnings show that high school inputs, in particular those related to teacher human capital (Becker 1964, 1975), have a statistically (and practically) significant effect on career earnings that is statistically indistinguishable across the three career points. The key proxies for teacher human capital are mean teacher years of experience, mean years of teacher experience within the district (tenure), mean teacher education levels, and mean teacher salary in the students' district. Our preferred estimates show that $1000 of additional teacher human capital (in 2010 dollars) raises earnings at each career point by 1.89-2.20 percent. We use this estimated treatment effect to calculate the returns to local school districts from investing in teacher human capital where returns are measured by the private earnings differentials graduates received from community investments in their educations. Using

[4] These data are available from the WLS (http://www.ssc.wisc.edu/wlsresearch/).

[5] Most districts had only one high school, so that district and school level data are identical. For the few districts with multiple high schools (e.g. Milwaukee, Madison), the measures capture district averages. This issue is addressed in detail later in the paper.

[6] 2011 survey data was not used because very few respondents were still working fulltime.

census data from 1960-2000 to establish a baseline earnings profile for Wisconsin high school graduates in this cohort, two equivalent values were calculated for a variety of specifications: the internal rate of return earned on an investment in teacher human capital and the net present value of the investment using a 5 percent discount rate. Depending on the model specification and whether it is assumed that district level investments observed in high school were also made during grades 1 through 8, the net present value of a 2010 dollar investment per student over either 4 or 12 years year ranges from $16 to $73.[7] Using the more conservative assumption that the investment occurred in all twelve grades, our preferred point estimate places the present value of the benefit from a dollar invested per student over 12 years at $17-20. The corresponding internal rate of return from this investment is 18-19 percent.

The remainder of this paper is divided into nine sections. The next section briefly reviews the literature on school quality and student outcomes. Section III describes key features of the data and Section IV describes our empirical specification. Section V presents the basic empirical results showing the effect of family background, school, and teacher characteristics on the earnings of the WLS subsample at the three points in the respondents' careers using a variety of teacher and school quality measures. Section VI presents robustness tests using alternative earnings measures, additional school, family and geographic controls, and different plausible sample definitions. Section VII estimates the relationship between school inputs and household retirement assets measured when the respondents are about 64 years old. Section VIII presents the estimated internal rates

[7] The present value in grade 1, using a 5 percent discount rate, of a $1 invested per student corresponds to an $0.113 investment per year and the present value at the beginning of grade 9 of a $1 invested per student over 4 years equals a $0.282 investment in each of the four years.

of return and the net present value estimates of school investments based on the results reported in Section V. Section IX provides a brief discussion and summary of our results.

II. Previous Research

In their 1992 study, Card and Krueger (1992) argue that the effects of primary and secondary educational inputs should be judged by the relationship between these school inputs and labor market outcomes observed several decades after students leave school. To investigate this relationship, they designed a study that permitted them to estimate the effects of school inputs on labor market outcomes for mature workers (who have been in the labor market for 20–45 years) without having school- or school-district-specific data on the resources individuals received when they were in school. This design was necessary because there were no existing individual-level panel data sets with earnings for mid-career workers that also included information on school inputs for the same workers.[8] Faced with this data limitation, Card and Krueger correlated earnings data for older cohorts by state of birth from the 1980 Census with state-level average school and teacher characteristics measured at the time respondents were in school for individuals who were living in a state different from their state of birth. They found that the return to a year of education declined with increasing pupil/teacher ratios and was positively related to relative teacher salaries.

[8] For example, the surveys by the National Center for Education Statistics (High School and Beyond Study of the Class of 82, and the National Education Longitudinal Study of the Class of 1992) contain a wealth of information about the respondent's high school experience but all stop before the respondents were 30. The National Longitudinal Study of the Class of 1972 continues a bit longer, but does not include sufficient school-level information.

Card and Krueger's study renewed interest in the topic, and led to more research over the next five years. Generally speaking, studies that relate school inputs measured at the school or school district level to career outcomes measured when workers are in their late twenties or early thirties fail to find a significant relationship (Betts 1996; Grogger 1996; Hanushek, Rivkin, and Taylor 1996), while studies that replicate the Card and Krueger methodology with other data find evidence consistent with Card and Krueger (Loeb and Bound 1996).[9]

More recently, new data and study designs have enabled researchers to develop a more nuanced understanding of the relationship between school inputs and student outcomes, reviving the literature yet again. Over the last decade matched student-teacher panel data and teacher-classroom panel data have been assembled for a number of cohorts in different states and large individual school districts.[10] Studies using these data have estimated teacher specific effects on student test score gains over one or more school years and consistently find that a high quality teacher, as measured by teacher fixed effects, has a large and significant impact on student learning relative to a low

[9] A variety of explanations have been offered to account for the conflicting results. First, it may be that microdata results are biased downward because the effects of school inputs on young workers are not yet reflected in wages. Second, it may be that measurement error is smaller in national studies that rely on state-level averages for school inputs than when inputs are measured at the district or school level, biasing microdata studies toward zero. On the other hand, comparing average returns across states may overstate the effect of school inputs on labor market outcomes If the correlation between state-level averages and unobserved state characteristics is greater than the correlation between school district-level measures and omitted family and local community characteristics affecting wages (Hanushek, Rivkin, and Taylor 1996). Fourth, the results may rely on model specification. Card and Krueger's empirical specification assumes no interaction between state of birth and state of residence on earnings but Heckman, Layne-Farrar, and Todd (1996a,b) show that their estimates change significantly when interaction terms between state of birth and state of residence are included in the model.

[10] See Rivkin, Hanushek, and Kane 2005; Harris and Sass 2011; Boyd et al, 2005; Aaronson et al. 2007; Jacob and Lefgren 2004, 2008; Goldhaber 2007; Chetty et al. 2010a, 2010b; Hanushek 2011; and Buddin and Zamarro 2009.

quality teacher.[11] For example, using data from Chicago public schools, Aaronson et al. (2007) find a one standard deviation difference in math teacher quality corresponds to a .18 to .21 grade difference in average yearly gains in student math scores.[12] Using data from a large urban district Chetty et al. (2010b) estimate the impact of test score gains measured by teacher fixed effects on the earnings of students when they are young adults. They find a standard deviation increase in teacher quality raises mean earnings at age 28 by 1.3 percent. By assuming this differential persists over the students' full careers and a 5 percent discount rate, they estimate that the present value increase to the lifetime earnings of a single student from have a one standard deviation better teacher for a single year is $7,000.

The studies using matched student-teacher or classroom-teacher data show that very little of the difference in measured teacher quality within a school or district is correlated with observed teacher characteristics. Although the vast majority of school districts in most states set a teacher's salary based on a salary matrix defined jointly by years of teaching experience and educational achievement, the studies using matched student-teacher data find that beyond the first few years of experience, variation in teaching tenure and education *within* a district is not related to a teacher's effectiveness as measured by her impact on student test score changes. This fact makes it very difficult to define the characteristics of a high quality teacher or to identify the steps necessary to

[11] Class size effects have also been studied in the Tennessee STAR field experiment where students were randomly assigned to classrooms with different numbers of students. Early studies found small positive effects of class size that persisted for a relatively short time period. See Schanzenbach (2006/2007) for a description of the experiment and the resulting studies. I SUGGEST WE DELETE. OTHERWISE UPDATE.

[12] See Table 9, columns 1-3, row labeled "Without School Effects: Adjusted Standard Deviation" in Aaronson et al. (2007).

improve the productivity of a low performing teacher despite the evidence that teacher quality matters for student outcomes.

This brief overview of the research provides the rationale for the present study. The data set we compile enables us to estimate the effect of school inputs on the earnings of individual high school graduates at three widely different career points while minimizing the potential sources of bias found in previous research. By matching school district level data to the WLS, we create a 50-year panel that includes very good measures of family background characteristics, student earnings at approximately 35, 52 and 64 years of age, and school district information from the districts these individuals attended measured at the time they attended high school. Most of the districts in the sample (95 percent) contain only one high school; therefore, there is virtually no aggregation of our school input measures. We minimize the effects of measurement error by calculating average school inputs over a 4-year period. Potential aggregation bias due to omitted state effects cannot be a confounding variable because the entire sample graduated from Wisconsin high schools.[13] Finally, while the Chetty et al. results linking test score gains to earnings are an important piece of evidence validating the use of test score gains as proxies for later career outcomes, the lifetime present value calculations they present are based on extrapolating the teacher treatment effects at age 28 to the next 30-40 years of a student's time in the labor force; the impact of teacher quality over the lives of the students in the Chetty sample will not be known for decades. In contrast, we are able to provide lifetime present value calculations of the effect of school quality

[13] Although the entire sample graduated from Wisconsin high schools, many respondents (28 percent) were living outside of Wisconsin at the time of the 1975 interview. These respondents are included in the analysis.

investments made over 60 years ago on the actual earnings of students throughout their careers.

III. The Data and Sample

In 1957 researchers at the University of Wisconsin–Madison began a study of a one-third random sample of the 1957 Wisconsin high school graduating class that continues to the present. This study, the Wisconsin Longitudinal Study (WLS), provides detailed information on respondents collected from public records and major surveys administered in 1957, 1964, 1975, 1992–93, 2004 and 2011. These data are of excellent quality and have been used in many previous studies across a variety of disciplines.[14] The data include detailed information on educational achievement and performance, family background characteristics, and labor market outcomes. For example, family household income for 1957-60 was obtained from Wisconsin State income tax records, making the WLS one of the first surveys to match tax earnings data from administrative records to individual survey respondents. The survey is broadly representative of white American men and women with at least a high school education (Hauser et al. 1993). One weakness of the WLS for our purposes is that the left censoring at 12 years of education means these data cannot be used to estimate the marginal effect of high school resources on the returns to graduating from high school.[15] Also, because the sample reflects the

[14] See Sewell and Hauser (1975) for a thorough analysis of the sample, Herd et al. (2014) for a description and history of the survey, and http://www.ssc.wisc.edu/wlsresearch/publications/ for a complete bibliography of research employing this data set.

[15] However, the censoring on high school graduation in the WLS is less severe than would have been the case if the sample had been collected in most other states. Data from the 1960 Census shows that 26.7 percent of 20-25 year old males living in Wisconsin had less than a high school education. In the entire nation 38.1 percent of males in this age range had less than a high school education. Out of the 50 states,

demographics of Wisconsin in the late 1950s and it does not include those who did not attend high school to completion, minorities are poorly represented in the sample; the data cannot be used to examine questions about the relative effect of school inputs on minority populations. Of course, it may also be the case that the particular circumstances of the 1950's affecting student outcomes are not relevant to the experiences of those coming of age today. However, this "weakness" is unavoidable when exploring a causal link between events distant in time.

Only limited school input data was originally collected by the WLS. Fortunately, the Wisconsin Department of Public Instruction (WDPI) has long required each school district to report key information about spending levels and personnel for grades 1-8 and 9-12.[16] We coded data from the high school annual reports for 1954–57 for 336 of the 421 Wisconsin school districts that had students in grades 9–12.[17] The only districts whose reports were not coded were those with fewer than five students in the full WLS. A dozen districts did not provide reliable information over any of the 4 years and were also excluded. Many of these districts were in the process of merging with other districts, making accurate data impossible to supply. These selection criteria produced a final sample of 4,126 male students who graduated from 308 different high schools in 275 public school districts. Of these districts, 261 contained only one high school and nine

---

Wisconsin had the fifth lowest dropout rate for males in this cohort. These calculations are based on the authors' tabulations from the 1960 Census using data extracted from the *Integrated Public Use Microdata Series v. 2.0* (Ruggles et al.1997).

[16] The original paper documents were transferred to microfiche in the 1980's.

[17] In 1956–57 there were 3,822 operating school districts in Wisconsin, including 2,612 one-room rural school districts and 789 "graded" schools that provided education through grade 8. The inputs received by WLS respondents when they were in grades 1–8 likely are correlated with the resources they received in high school. Thus, the estimates reported here may partially reflect the effect of school inputs in the earlier years. We take this possibility into account when we calculate the rates of return on student earnings from local investments in education.

districts contained only two high schools. Our data set includes at least one observation from school districts that collectively enrolled over 80 percent of the total population of seniors in the state in 1957. The number of observations per school district in the sample ranges from one observation for 16 districts to 306 students from the Milwaukee public school system.

Unless the reports were incomplete, the following variables were constructed for each of the four years and attached to each student's record:

- Length of the school term
- Percentage of the teaching staff with more than 4 years of post-high school training
- Mean years of teaching experience of high school teachers in the district
- Mean years of district tenure of high school teachers in the district
- Pupil/teacher ratio
- Mean salary of teachers in the district

Mean values over the 4 years (or all available years) were calculated. Averaging was done because average values capture any real changes in school inputs over the 4-year period that may have had an impact on student achievement and mitigate potential measurement error in districts that were stable.

Of the original WLS sample of 4,991 males, 3,194 met all requirements to be used in this analysis in at least one year. The sample was constructed by restricting the original 4,991 to those who attended schools for which data was coded (4,126 males), those who supplied complete information on family-level variables (3,243) and those who provided income data in at least one year, derived a majority of his income from wages or salary, and was not primarily a farmer. (Farmers were eliminated because their reported earnings likely reflect returns to land and capital.) The sample sizes vary across the three years based on the number of respondents that met the earnings requirements in that survey year, with 2,608 observations in 1974, 2,283 observations in 1992, and 920 observations in 2004. The smaller number of observations in 2004 reflects the large number of respondents who were retired or no longer alive in 2004.[18] Although there was some attrition due to nonresponse, as we would expect over more than 40 years, the response rate in the WLS is unusually high. In Section VI we report results from alternative samples, earning measures and an expanded set of family and respondent characteristics.

Table 1 shows the mean values and standard deviations for various family characteristics of the WLS respondents and a variety of the school resource variables. For each variable data are reported for the entire sample in Column 1 and separately for the respondents or districts in each of the three survey years (Columns 2 through 4). The district-level information in Columns 2 through 4 reflects only those districts represented by a respondent in that year. Family income from 1957-61, mean district teacher salary data and respondents' income at all three career points are in 2010 dollars using the CPI.

The average values of parental income and parent education levels for the final sample of WLS respondents are very similar to mean values for comparable families in Wisconsin. Using the 1960 Census, we compared Wisconsin white households that included at least one male child in high school to our WLS sample.[19] There was virtually no difference in parents' education among the parents of our WLS subsample compared

[18] Nine percent (293) of the respondents in our original subsample died over the 1993-2004 period and 920 reported being retired. 414 respondents included in the 2004 earnings model report their retirement status as "partly retired." Sample members were around 64 years old in 2004.

[19] Authors' tabulations using data extracted from the *Integrated Public Use Microdata Series v. 5.0* (Ruggles et al. 2010).

to the comparable sample from the 1960 Census. Average years of father's education in the census sample was 10.28 years, compared to 10.04 in the WLS (standard errors are .060 and .052 respectively). For Wisconsin mothers, the mean years of education in the census was 10.73 and 10.63 in the WLS (standard errors are .075 and .041, respectively). Comparing average family income in the 1960 Census with the WLS sample is more difficult. Family income was obtained by the WLS from the Wisconsin Department of Revenue state income tax records and equals the average reported household nominal income for the years 1957–1960 while the Census data is the self-reported household income for 1959. The comparisons show a median value for total family income of $49,493 (standard error is 535) for the census families and a median value of $41,213 (standard error is 297) in the WLS. These calculations suggest that families in our WLS sample had incomes lower than comparable Wisconsin families in in the 1960 Census. Some of this difference may reflect differences in time periods covered, differences between households and tax units, discrepancies between taxable income and self-reported family income, the lack of inflation adjustment in the original WLS family earnings data and the exclusion of WLS students enrolled in private high schools.[20]

IV. The Statistical Model

The statistical model of earnings we estimate is a reduced form specification where log real annual earnings is a linear function of observed family background characteristics, secondary school inputs, and a set of unobserved characteristics:

[20] In the 1960 Census it was not possible to determine if students attended public or private high schools.

(1) $$\ln Y_{i,t,s,d} = \beta_0 + \sum_t \sum_k \beta_{t,k} Q_{d,t=57} + \sum_t C_t Z_i + \upsilon_d + \alpha_s + u_i + \varepsilon_{i,t,s,d}$$

where $Y_{i,s,d,t}$ is real wage and salary income in year *t* for respondent *i* (*t=1974, 1992, 2004*) who attended high school *s* in school district *d*, $Q_{d,t=57}$ includes a set of k measured school inputs provided during high school for students that graduated in 1957 from district *d*, and Z_i is a vector of family background characteristics for individual *i* measured when the individual was in high school. In the most unconstrained model the coefficients $\beta_{t,k}$ and C_t are allowed to differ across the three time periods. The unobservables in the model are unmeasured district and community characteristics (υ_d), unmeasured high school characteristics (α_s), unmeasured individual characteristics (u_i), including unmeasured family characteristics, and a random component that is assumed to be independent across time, individuals, schools and districts. This reduced form model assumes intervening variables between 1957 and year *t* such as additional years of schooling or the extent and type of work experience up to year *t* that may have causal effects on earnings in year *t* may also have been affected by high school inputs and family background characteristics. Since the main focus in this study is on the impact of these two sets of variables on career earnings, this reduced form model provides estimates of these effects without having to measure and properly specify more complicated models of the impact of high school and family characteristics on these intervening variables and the impact of these intervening variables on later earnings. The standard errors are clustered at the school district level when models are estimated separately for each year and clustered at the individual level when the data for the three years are pooled.

The three primary exogenous variables that form the Z matrix of family background characteristics are each parent's education and family income. These variables have been found to be significant predictors of future outcomes in previous work using the WLS (Hauser et al. 1993), and other data (Altonji and Dunn 1996; Betts 1996). We assume the WLS earnings measure (mean nominal income for 1957-1960) is highly correlated with family income from 1954-57 when the WLS respondents were in high school. All the monetary variables in Equation 1 are expressed in 2010 dollars, adjusted using the CPI.

V. Estimates of the Effects of School Inputs on Career Earnings

Tables 2a through 2c report the ordinary least squares estimates of models where the natural log of real annual earnings ($2010) is regressed on functions of the educational levels of each parent, average parental income, and school input measures at each of the three career points. For 2004 earnings an additional indicator variable was added that was equal to one if the respondent reported being "partly retired" in 2004. Earnings are defined as wage and salary income for individuals for whom this is the major source of income.[21] Column 1 of each table reports estimates for a model that includes six school input measures commonly used in previous research – the length of the school year, the fraction of district teachers with more than four years of college training, mean years of

[21] Wage and salary income is more than 50 percent of wage and salary income plus income from self-employment.

teacher teaching experience, means years of teacher tenure in the district, the pupil/teacher ratio, and the mean teacher salary in thousands. None of the individual school resource coefficients are individually significant at the .05 level in any of the three years, but the joint hypothesis that all six coefficients are equal to zero is rejected in each year with a p-value less than .0001 in 1974, .0023 in 1992 and .0932 in 2004.

Columns 2 through 7 in Tables 2a-2c show models where each resource variable is entered individually. In all three years, coefficients on teacher education, teacher tenure and mean teacher salary are in the expected positive direction and statistically significant at the .05 level using a one-tail test. Mean teaching experience is statistically significant in 1974 and 1992 and the length of the school days is significant in only 1974. The coefficient on pupil/ teacher ratio is always positive but never statistically significant. The joint hypothesis that teacher salary and the teacher human capital variables (teacher experience, teacher tenure, and teacher education) are jointly equal to zero is rejected with a p-value equal to .0002 in 1974, .0019 in 1992 and .034 in 2004. In contrast, the joint hypothesis that the effects of school year length and the student/teacher ratio are different from zero cannot be rejected at the .2 level in any of the years. We take these results as support for the hypothesis that across districts, differences in average high school teacher quality had a significant impact on the earnings of WLS males throughout their careers while school year length and pupil/teacher ratio did not. Therefore in subsequent models we focus on the teacher salary and human capital variables.

To test the differences between the effects of teacher salary and human capital variables across the three periods, a pooled model was estimated that included indicator variables for 1992 and 2004 and interaction terms between the period indicators and all the other variables in the model. This specification permits us to test if the effects of the teacher human capital variables differ across the three periods while allowing error terms to be correlated over time. The p-values for various statistical tests are reported in Table 3. Columns 1 through 4 report the p-values for models where the only school district/teacher characteristic is the one listed (family characteristics are always included). For example, Column 1 reports results for mean teaching experience. The coefficient on this variable is .0345 (standard error .0068) when it is constrained to be the same across all three periods. The hypothesis that the effect of this variable on WLS earnings is the same in all three periods is not rejected with a p-value equal to .927. The hypothesis that the effect is the same in 1992 and 2004 is not rejected with a p-value of .915; the p-value that the effect in 1992 is different from 1974 is .698 and the p-value that the effect in 2004 is different from 1974 is .957. Thus, the data show that in a model with only mean total teaching experience, its effect on earnings does not differ across the three career points. Columns 2 through 4 reports similar results for the other teacher quality variables.

Panel B of Table 3 report the constrained coefficients and p-values for joint hypotheses on a single teacher variable in models with all four teacher variables included plus interactions between all four variables and the two year indicators. For example, the .618 in Column 5 is the p-value for the joint null hypothesis that the effects of mean years of total teacher experience is the same across all three years in a model that includes the other three teacher variables and their interactions with the two year indicators. Like the results reported in Panel A, these results fail to reject the hypotheses that the impact of each teacher variable on earnings are the same at all three career points at a p-value of less than .05. There is no evidence to suggest that the effects of these teacher human capital variables differ across the three careers points for males in the WLS

Standard neoclassical theory predicts that teachers will be paid based on their productivity. The results reported in Table 3 show that teacher productivity, as measured by later student success in the labor market, is a function of the education, teaching experience, and tenure of teachers in a district. This suggests the impact of teacher human capital in a district on student performance can be summarized by the prices paid by districts for units of teacher human capital (education, experience, and tenure) and the levels of teacher human capital chosen by each district. Thus, the average teacher salary in a district is a plausible summary measure of teacher quality in a district and it is predicted to be related to the later career earnings of students. The results in Column 4 of Table 3 clearly support this conclusion. These estimate shows that mean real teacher salary had a significant impact on wage and salary income at all three career points. The .0085 coefficient implies that a standard deviation difference in the mean teacher salary raised earnings by 3.03 percent ($e^{(.0085*3.508)}$-1) throughout a student's career.

While the mean salary of teachers in a district reflects the average levels of teacher human capital, teacher salaries also reflect other factors, including geographic differences in the cost of living and compensating differentials for job characteristics such as larger class sizes or a longer school year. Table 4 reports estimates of alternative models predicting mean district salary for the 280 districts included in this study. The first model includes only the three teacher human capital variables and the second model adds an expanded set of covariates, including the pupil/teacher ratio, the length of the school year and four geographic indicators denoting different parts of the state. The expanded specification better fits the data (larger R^2s). The additional variables in the model are jointly significant (p-value is less than .0001) and the three teacher human capital variables remaining significant with only a small decrease in magnitude.

Table 5 presents results from a 2-stage regression where predicted teacher salary and a residual term are included as variables in the WLS wage model based on the regressions from Table 4. In column 1 the coefficient .0157 is the coefficient on the predicted teacher wage for a district constructed using the teacher wage regression results in column 1 of Table 4 and the values for each of the three teacher human capital variables in each district. The .0116 coefficient in column 2 of Table 5 is coefficient on the predicted teacher salary for a district using all the variables (teacher human capital and the non-teacher human capital variables) included in the regression model in the second column of Table 4. The estimated coefficient in column 3 of Table 4 is the coefficient on the part of a district's mean wage explained by only the teacher human capital variables included in the regression in column 2 of Table 2. In other words, the .0186 in column 3 of Table 5 is the coefficient on the following variable for the ith district:

$$\widehat{Salary}_i = .411 * Experience_i + .322 * Tenure_i + 7.781 * Tcher\ Educ_i$$

To aid comparison, Column 4 of Table 5 repeats the result from Table 3 where the mean teacher salary is entered directly.

If the predicted teacher salary based on the three measured teacher human variables captures all of the difference in teacher productivity (as measured by their impact on later student earnings), then the model with predicted salary should fit the data as well as a model that includes all three variables individually. In addition, the residual term will not be significant unless there are remaining unmeasured teacher characteristics that are correlated with the earnings of WLS graduates but orthogonal to the predicted wage. In all of these models the coefficients on the residual term is small compared to the coefficient on the predicted wage terms and not statistically significant at the .10 level. In contrast, across all three models the coefficient on the predicted mean teacher salary is significant at the .01 level and all three parameter estimates in columns 1-3 are larger than the .0085 coefficient on mean real teacher salary in Column 4. The smallest of the three coefficients (.0116) uses the predicted wage from the expanded model where the variation in the predicted wage is due to both the teacher human capital measures and the expanded set of covariates that do not reflect differences in teacher human capital. In contrast, the largest coefficient (.0186) uses the predicted salary variation from only the three teacher human capital measures and the coefficients on these variables from the expanded teacher salary model that controls for regional variation, average class size and the length of the school year. The .0186 coefficient is over twice the size of the coefficient on mean teacher salary. Since variation in mean teacher salary reflects variation in both average teacher human capital *and* variation other compensable factors (location, class size and school year length), comparing Column 4 with the other columns shows that it is the variation in mean salary due to variation in the stock of teacher human capital that had a significant impact on the earnings of male high school graduates, rather than other school characteristics affecting teacher salaries. The estimates in Table 5 suggest that the teacher labor market over this time period priced teacher education and experience in a manner that captured the variation in teacher productivity.

The predicted average teacher salary variables constructed from the models in Table 4 are simply linear combinations of the variables in the wage model where the chosen OLS weights maximize the variation in mean wages explained by the variables included in each model. While the largest coefficient in the WLS earnings model is on the predicted mean teacher wage using only the three teacher human capital measures and coefficients from the expanded wage model (column 2, Table 4), this particular linear combination may not be the variable that best captures the impact of mean teacher wages and the three teacher human capital variables on WLS earnings.

To gain an understanding of the economic significance of the estimates reported in Table 5, the last row in Table 5 shows the estimated impact of a standard deviation change in the teacher wage measure on WLS earnings at the three career points. All the models produce very similar estimates and show a standard deviation increase in mean teacher human capital in a district raised the earnings of the students at the three career points by 3.03 to 4.35 percent and the median across the estimates is 3.77 percent. These estimates suggest differences in average teacher quality in Wisconsin high schools in the 1950s had a substantial impact on the lifetime earnings of their male graduates.

VI. Robustness Checks: Alternative Model Specifications & Samples

The estimates presented so far will be biased if unobserved characteristics of the WLS respondents are correlated with their career earnings and the teacher human capital measures. Evidence regarding this possibility can be obtained by comparing the results from two Hausman tests where the coefficients on parents' education and income in a random coefficient model are compared to the coefficients on parents' education and income in a model that includes district fixed effects[22] Although we cannot estimate the coefficients on the teacher human capital variables in a fixed effect model, we can use a Hausman test to compare the coefficients on parents' education and income in a fixed effect model with the coefficients on these same variables in two random coefficient models where the teacher human capital variables are included in one specification and excluded in a second specification. [23] We expect to reject the equality of the coefficients on family income and parents' education in the fixed effect model and the random coefficient model that excludes the teacher human capital measures because we expect families with higher incomes and better educated parents will sort into districts that employ higher quality teachers. Thus, the coefficients on family income and parents' education will be biased in the random coefficient model without the teacher human capital measures.

In contrast, if we fail to reject the hypothesis that the coefficients on family income and parents' education are the same in the fixed effect model and the random coefficient model that includes the teacher human capital measures, then we can conclude the coefficients on parents' education and income in the random coefficient model are unbiased because controlling for teacher quality in a district captures the community characteristics affecting the earnings of WLS graduates that are correlated with family income and paarents' education. This result also means the coefficients on teacher

[22] The test is whether the coefficients on parents' education, family income, the two year dummies and the interactions between the year dummies and the family background variables are the same across the RE and FE model.

[23] The teacher human capital measures cannot be included in the fixed effect models because the impact of teacher quality is absorbed by the district fixed effects because all respondents in a district have the same values for the teacher human capital measures.

human capital are biased in the random coefficient model only if there are unobserved district or community variables correlated with mean teacher quality in a district and mean WLS earnings but uncorrelated with mean family income and mean parents' education levels in a district. We think the possibility of omitted school or community characteristics correlated with teacher quality but uncorrelated with mean family income and mean parents' education is unlikely.

The first row of Table 6 shows the p-values for the hypothesis that the coefficients parents' education and income are equal in the RE and FE models across the different specifications where the RE model includes the predicted teacher salary based on the regression results in Table 4. The results are consistent across all the models; there is no evidence that there are constant unmeasured community characteristics affecting wages that are correlated with the family background variables. This implies the set of unmeasured community or district characteristics that could bias our coefficient on teacher human must be correlated with the teacher human capital variables but not correlated with parents' education and income. As explained earlier, we believe the possibility of such an omitted variable is limited.

The second row in Table 6 reproduces the coefficients on the teacher salary variables reported in Table 5 where the model includes parents' education and household income, year indicators and interactions between the year indicators and the three family background variables. The third row in Table 6 reports the coefficients on the same teacher salary variables in models that include an expanded set of family variables and an additional school variable. These variables include an indicator variable for if the respondent grew up on a farm, an indicator denoting if both parents were present in the household when the respondent was in high school and the total number of siblings in the family. An additional school variable identifies high schools that offered a curriculum that would meet the University of Wisconsin-Madison's admission requirements. In all cases these variables were interacted with the two period indicators. The results in row 4 report estimates for models that also include two high school size indicators (51-199 students, > 199 students), dummy variables for students in Milwaukee, districts in the greater Milwaukee area outside of Milwaukee and indicators for districts in each of the five regions of the state designated in the 1950 Census. Across nearly all alternative specifications, the coefficients on the teacher salary variable are virtually unchanged from Table 5.

Row 5 of Table 6 report models that include the additional family control variables and add a set of dummy variables for each of the 70 counties in the state. These estimates show that variations in teacher salaries and the human capital of the teaching workforce in districts *within counties* had a significant impact on the earnings of WLS respondents across the three periods. While the standard errors are slightly larger with the county fixed effects, the point estimates remain virtually unchanged and significant at the .01 across almost all the models.

Since all students in a district are assigned the same mean school district resource variables, these variables are not going to accurately reflect resources available to students in a high school for districts that have more than a single high school unless resources are divided equally across all the high schools in a district. If resources are not equally divided among high schools in a district, our district level measures will measure resources available in a school with error, biasing our estimates toward zero. This is likely to be a confounding factor for respondents from Milwaukee where our sample is distributed across 14 high schools; almost 10 percent of the individuals in our WLS subsample graduated from Milwaukee schools. In the sixth row of Table 6 we report estimates for our models that exclude Milwaukee graduates. Across all the models the point estimates are larger from the estimates that exclude Milwaukee students. This is exactly what we'd expect to happen because of the measurement error in the resource measures assigned to Milwaukee high schools. Finally, the last row of estimates in Table 6 report coefficients using respondents that were in a district with a single high school. These estimates are slightly larger than the estimates row 2, which is not surprising because we've eliminated measurement error due to assigning the same resource values to all high schools in districts with multiple high schools.

In Table 7 we report estimates using either alternative samples or alternative income measures in models that control for our original three family background measures (parents' education and income). Recall the estimates in the previous tables are based on the wage and salary income of respondents in periods where their wage and salary income was greater than zero and at least 50 percent of their total income came from employment and not self-employment or farming. These are repeated in Row 1. The second row report estimates where the sample includes all individuals with positive wages, including semi-retired individuals. For this sample the dependent variable is real salary income and wage and salary income. For this sample the table also reports the point estimate divided by the sample mean and the standard error of this value in Row 3 so that these estimates can be compared with models using ln(earnings). In Row 4 the earnings are the sum of wage and salary income, self-employment income and farm income and the dependent variable is the natural log of the real value of this sum. Those with zero earnings are excluded. The estimates across these different samples and definitions of earnings are very similar, suggesting are results are robust to plausible differences in how earnings are measured and in which types of earners are included.

We conclude from these results that our baseline model estimates are robust to the inclusion of very detailed sets of geographic controls, additional family and additional high school characteristics; there is no evidence to suggest unmeasured variables are correlated with the variation in school resources across districts and biasing our estimates. The larger point estimates obtained when respondents from districts with more than one high school are excluded is consistent with the introduction of measurement error in the teacher human capital measures when a district average variable is assigned to students attending different high schools within a school district. In summary, the results in Tables 6 and 7 support the conclusion that our estimates reflect the causal impact of teacher human capital on the lifelong career outcomes of Wisconsin students in the 1950s.

VII. Impact of School Quality on Assets Owned at Age 64

In this section, we explore the effect of the same school resources, particularly teacher inputs, on asset accumulation using data collected in 2004 as the respondents' working lives were ending. The 2004 WLS contains detailed information about individual and family assets, including self-reported estimates of net worth, estimated home equity, and own and spouse retirement investments.[24] Any plausible model of lifetime earnings and savings leads to the prediction that at least some of the higher earnings resulting from district purchases of high quality teachers would have been saved or invested for retirement or end-of-life expenditures. Thus, if students graduating from higher quality high schools have higher earnings throughout their careers, we should expect to observe greater individual or family assets accumulated by 2004, and a statistical relationship between assets and our measures of school quality.

Table 8 reports OLS estimates of the effects of teacher human capital on the conditional mean of various 2004 asset measures using our standard reduced form model that controls for parents' education and family income (coefficients not presented). The sample sizes in these models are smaller than in the earnings model because we are only looking at asset holdings in a single period and by 2004 many of the original respondents had passed away.[25] However, the samples are substantially larger than the 904 individuals included in the 2004 earnings sub-sample because asset data was collected for many respondents who reported being fully retired.

The first three columns report the estimated coefficients on the mean teacher salary and the two measures of predicted teacher human capital constructed from column

[24] The WLS also includes information on pensions. Individuals were asked if they were receiving payments from a private pension, when the payments began and the size of the pension. If they weren't receiving a pension, they were asked if they expected to receive a pension, when did they expect to receive it and how much were they expecting. We did not find these variables to be related to high school inputs. We think this is because it is very difficult to calculate the pension wealth of respondents who were already receiving a pension because no information is available on the size of the pension payments they received in earlier periods or the "penalty" they may have taken to retire before normal retirement age.

[25] Of the original 4991 males in the WLS, by the time of the 2004 survey 1315 had died (26 percent). The sample was reduced further because not all surviving respondents could be contacted by phone for the interview. Data in 2004 was collected on a total of 2473 males that attended high schools for which we had school resource data.

2 of Table 4. Each row in Table 8 reports estimates of teacher human capital on different 2004 household asset measures. The first row reports estimates for total household net worth. This is a self-reported answer to a single question. Included in the sample are a small number of respondents (60) that reported zero or negative values for net worth. For the model in column 2, a standard deviation increase in district human capital per teacher (2.2) in translates into almost $52,415 (23825*2.2) of additional household net worth in 2004. This is equal to 12.5 percent of the median value of household net worth in the sample.

The second row shows results for reported home equity.[26] A standard deviation difference in district teacher human capital is associated with a predicted 9.8 percent difference in home equity evaluated at the median value of home equity in the sample. The third row reports results for a constructed asset variable equal to household net worth minus home equity. For respondents that had missing values for one of these two asset types the value was set equal to the value of the non-missing variable. The point estimates on this variable are plausible because they are close to the difference between the coefficients in the first two rows. However, these coefficients are estimated very imprecisely, suggesting a lot of measurement error in reported net worth after subtracting out home equity.

The last row reports estimates for models where the dependent variable is household assets held in defined contribution pension plans such as 401(k) plans, IRAs and firm profit-sharing plans. These estimates show substantially larger retirement

[26] Renters are included in the sample and home equity is set to zero for these respondents.

savings for graduates from schools where teachers had more human capital. Using the estimate in column 2, a standard deviation difference in the human capital measure corresponds to a $29,348 difference in retirement assets which is equal to 29.3 percent of the median value for this dependent variable.

A set of calculations using these estimates were performed to assess whether these estimated effects on assets are consistent with the estimated effects of school quality on earnings at the three career points, assuming these estimated earnings effects apply over the entire career of a male WLS respondent. The implied share of the earnings differential attributable to a standard deviation difference in teacher quality (exp(2.2*.0186)-1) that would have to be invested each year was calculated to produce asset holdings equal to the coefficient from column 2 in Table 8 times a standard deviation increase in teacher quality (2.2). These estimates were performed using two different real rates of return on the savings. In one set of calculations it was assumed from 1964-2004 the savings balance earned the real rate of return on the S&P 500 stock index minus a 1 percent nominal investment fee on the balance and in the other set of calculations returns equaled the annual real rate of return on a 90 day U.S. Treasury bill.[27] The annual savings rates obtained from these calculations are reported in Columns 4 and 5 of Table 8.

[27] In year t the balance in the investment account earned an annual real rate of return equal to $(1+nominal_ret_t -.01)/(1+inflation_rate)-1$where $nominal\_ret_t$ was either the nominal annual return on the S&P 500 market index, calculated from December to December changes in the index, or the average annual yield on a 90 day Treasury bill in December of each year. The median annual real return on the S&P portfolio minus 1 percent/year in expenses over the 41 years was 6.02 percent and a median 1.53 percent real return on a portfolio of T-bills.

Focusing on own and spouse's net worth, if a household invested 3.5 percent of the earnings differential attributable to a standard deviation difference in teacher human capital (2.2) using the estimates from column 2 of Table 8 in the S&P 500 each year, in 2004 they would have a portfolio worth 2.2 times the estimated impact of $23,825 reported in row 1, column 2 of Table 8. If the money was invested in much safer U.S. Treasury bills 27.8 percent of the earnings differential would have had to been saved to accumulate the household net worth attributable to the predicted effect of a standard deviation difference in teacher human capital on net worth in 2004. These implied saving rates for these two portfolios suggest the impact of teacher human capital on assets held in 2004 are generated by the causal impact of teacher human capital on the career long earnings trajectory for male WLS students.

VIII. Estimated Rates of Return to Investments in Teacher Quality

The estimates reported in the previous sections provide strong evidence of a positive and significant effect of school quality, as measured by the market value of teacher human capital in a school district, on the lifetime earnings of male Wisconsin high school graduates from the late 1950s. All else equal, districts that paid higher teacher wages bought better-educated and more experienced teachers, who in turn produced graduates who were measurably higher earners throughout their careers. Our preferred measure of the market value of average teacher human capital is the value calculated using the coefficients on the three teacher human capital variables from the expanded teacher salary model reported in the second column of Table 4 and analyzed in Column 3 of Table 5. These coefficients gives an estimate of the value of teacher human capital based on a model that also controls for regional differences in pay across the state and pay differences due to differences in the pupil/teacher ratios and the length of the school year. The point estimate on this variable in WLS earnings model that controls for parents' education and income is .0186 (column 3 in Table 5).Recall that teacher salary is measured in thousands of 2010 dollars so the point estimate implies a $1000 increase in teacher human capital raises WLS earnings by 1.88 percent ($\exp^{.0186}$-1) and a standard deviation difference in the value of teacher human capital ($2200) leads to a predicted 4.18 percent earnings increase.

Since our school resource measures are at the school district level, our best measures of resources are for school districts that have only a single high school; in districts with more than one high school each high school was assigned the district average which likely includes more measurement error because resources were probably not distributed equally across high schools within a district. When the sample is restricted to students from districts with a single high school the .0186 point estimate increases to .0218 (Table 6, column 3, row 7) or a 2.2 percent salary difference for a $1000 of teacher human capital.[28]

In this section, we quantify what these two point estimates imply for the private rate of return students received from marginal increases in teacher quality and, equivalently, the net present value of investing in teacher quality using a 5 percent discount rate. We use these estimates to answer the following question: if local taxpayers wished to spend more on their children's education, what would be the return they could

[28] This subsample of high schools excludes all the districts in larger cities as well as many wealthy districts.

expect as measured by the higher labor market earnings their children would receive throughout their careers? We calculate two measures of the returns to this hypothetical investment. One measure is the internal rate of return (IRR) from the investment or the rate of return that sets the present value of the cost of additional teacher human capital equal to the present value of the career long earnings differential due to investments in teacher human capital. The second measure is the net present value (NPV) of an investment in teacher human or the difference between the present value of the career long earnings differential minus the present value of a investments in teacher human capital costs generating the observed earnings differential using a 5 percent discount rate.

To perform these calculations a number of assumptions were made about how teacher human capital resources were invested in the WLS respondents during high school. While we don't know average class sizes in each high school during this time period, we can calculate the high school pupil/teacher ratio. Therefore, we assume a dollar invested in the human capital of a single teacher is spread across k students where k is the pupil/teacher ratio in a district.[29] A second key assumption that must be made is the number of years WLS students in different districts were exposed to the differences in school resources we measured for grades 8-12 for each district. One assumption we make is that the resource differences we observe across districts are independent of resources invested in these students when they were in grades 1-7. Under this assumption our calculations assume resources difference we observed correspond to investments made

[29] A final assumption important to these calculations is that teacher investments equally benefit male and female students. Since all public high schools in Wisconsin in the 1950s were coeducational and we are only estimating the benefits received by males, we are implicitly assuming male and female students received the same inputs from their teachers.

over a four year time period when the students were in high school and these investments are orthogonal to investments made in earlier grades. This is an unrealistic assumption. If districts that invested more in their high school teachers also invested more resources in these kids when they were in grades 1-7, our point estimates would overstate the effect of high school investments because of the omitted bias caused by unobserved investments when the students were in grades 1-7. To account for this possibility in our IRR and NPV calculations, we make the alternative assumption that the differences in district high school teacher human capital investments we observe in our data correspond to investment differences when these students were also in grades 1-7. In other words, we assume school district investments extend over a 12 year period rather than a 4 year period. If students are six in grade one, then 12 years of investment occurs from ages 6-17 and four years of investment in high school are made when the students are 14-17 years old.

Evaluated at the mean teacher salary, the internal rate of return (IRR) associated with a standard deviation (SD_{HC}) increase in expenditures on teacher human capital is the value of IRR that solves the following equation:

(2) $$\ln Y_{i,t,s,d} = \beta_0 + \sum_t \sum_k \beta_{t,k} Q_{d,t=57} + \sum_t C_t Z_i + \upsilon_d + \alpha_s + u_i + \varepsilon_{i,t,s,d}.$$

(3) $$\sum_{t=L}^{17} \frac{-SD_{HC} * {}^{1000}/_{k}}{(1+IRR)^{t-L}} = \sum_{t=25}^{65} \frac{(e^{\beta_{HC} * SD_{HC}}) * \hat{Y}_t}{(1+IRR)^{t-L}}.$$

and the NPV equals:

(4) $$\sum_{t=25}^{65} \frac{(e^{\beta_{HC} * SD_{HC}}) * \hat{Y}_t}{(1+.05)^{t-L}} - \sum_{t=L}^{17} \frac{-SD_{HC} * {}^{1000}/_{k}}{(1+.05)^{t-L}}.$$

where:

k	=	average pupil/teacher ratio (21.8 in our sample),
$\hat{Y}_t$	=	baseline log real earnings in year t for a male Wisconsin high school graduate from the class of 1957 ($2010), and
β_{HC}	=	the estimated effect of spending an additional $1000 on teacher human capital on the log wage of a graduate in year t.
L	=	6 or 14 for either 12 or 4 years of investments in students.

The left hand side of Equation (3) is the discounted cost of spending an additional SD_{HC}*1000/k (measured in $2010) per student per year for 4 or 12 years discounted back to when the student was entering either first or eighth grade where the discount rate is IRR. The right hand side of Equation 3 is the career long earnings differential discounted back to either first or eighth grade using IRR. Equation (4) is similar but IRR is replaced with a 5 percent discount rate and the difference between the two terms is the present value of the benefits minus the present value of the cost of the teacher human capital investments. In these calculations we assume no returns from school quality are realized before age 25 and the respondent had no earnings disruptions between ages 25-65 due to unemployment or any other reason.[30]

$\hat{Y}_t$ is the baseline earnings in year t for an average 1957 Wisconsin high school graduate (male) in the absences of the treatment of an additional SD_{HC}*1000/k dollars of teacher human capital while in school. Since the WLS provides earnings estimates at only three points in time, using only the WLS data to identify the yearly earnings profile of

[30] Whether school quality reduced the incidence or length of unemployment spells is beyond the scope of this study, but certainly deserves further investigation.

Wisconsin graduates at each year in their career is likely to produce a very poor measure of $\hat{Y}_t$. Therefore, to estimate $\hat{Y}_t$ we used data from the U.S. Census from 1960-2000. From each of the five censuses we identified Wisconsin-born white males with at least a high school education who worked fulltime, full-year in the previous year that fell within a five-year interval that would have included the 1957 graduates, or the ages drawn from each census were:

Census	**Ages**
1960	18-22
1979	28-32
1980	38-42
1990	48-52
2000	58-62

The median earnings for individuals at each age (25 data points) are plotted in Figure 1 with the regression line through the points that has a cubic in age and a R^2 equal to .94. This line is used to define $\hat{Y}_t$.

Table 9 reports the estimates of IRR and NPV for the two point estimates (.0186 and .0218) of the effects of teacher human capital on WLS career earnings. A standard deviation difference in teacher human capital represents a $109 difference in teacher inputs per year measured in 2010 prices. The second set of rows show calculations where this $109/student investment is made for 12 years and the third set of numbers refer to calculations where investments are made for just the four years in high school. The estimates of the IRR range from 18 to 36 percent; our preferred estimates are 18-19 percent where investments are made over 12 years. The NPV calculations suggest that in a district where local taxpayers chose to invested a standard deviation more in teacher human capital for these students in grades 1-12, the net present value of this investment was \$16,000-\$19,000 or an internal rate of return of 18-19 percent on this investment as measured by the higher earnings children in the district realized during their adulthood because of their investments. Equivalently, each dollar invested in teacher human capital over a 12 year period or an investment of about \$0.113 per student per year returned \$17-\$20 in discounted higher earnings for each student or a NPV of \$16-\$19.[31] These are very large returns to local taxpayers who valued the futures of the children educated in their local public schools.

These estimates can be compared to the returns to alternate investments these families could have made. A dollar invested in the S&P 500 in 1945 when the WLS students were in the first grade would grow to a real value of \$7.54 in 2004.[32] The implied internal rate of return on the S&P 500 index that sets the present value of the \$7.54 value to one dollar in 1945 is 3.424 percent. This rate of return can be compared with the 18-19 percent IRR from investments in teacher human capital. The much higher return from investing in children compared to investing in the stock market suggests Wisconsin parents in the 1945-57 period were significantly under-investing in their children or they placed a low value on their children's future welfare compared to their current economic welfare. This could reflect the immediate aftermath of WW II and its impact on the preferences of local taxpayers. Over this period the Federal government and individual households were making significant investments in the human capital of WW II veterans and this may have had an impact on the resources available for direct

[31] The present value (using a 5 percent discount rate) of investing \$0.113 per student per year for 12 years equals \$1.00.

[32] The mean real annual return on the S&P 500 index over the 1945-2004 period was 5.08 percent (the nominal return on the index was 9.08 percent) (authors' calculations).

investments in children. Alternatively, since Wisconsin schools at this time were primarily financed by local property taxes, these large returns may reflect real constraints facing the ability of small asset poor communities to raise revenue to invest in their schools.

IX. Summary and Conclusions

In this study we have presented new evidence supporting a large positive relationship between the human capital of high school teachers purchased by local school districts and the lifetime career earnings of male students graduating from the high schools where they taught. The analysis is based on a random sample of males graduating from Wisconsin high schools in 1957 and their earnings in 1974, 1992 and 2004. We find a large impact of school resources on the career earnings of students that is undiminished throughout the careers of the respondents (as measured when the respondents are in their mid-thirties, early fifties and about 65). We believe these are the first estimates of the impact of high school resources on the earnings of students at such different points in their careers. Our preferred estimate of average teacher human capital is the predicted average teacher salary differences across districts due to mean differences in average teacher experience and education. After controlling for parents' education and income, we find a that $1000 ($2010) increase in average district teacher human capital led to a predicted 1.88 – 2,20 percent increase in the earnings of male high school graduates at each of the three career points. Our estimates remain virtually unchanged across alternative specifications, including models with very fine grain geographic controls (county indicators), additional family background characteristics and with different definitions of earned income. We also find large effects of high school teacher human capital on the assets owned by students 47 years after they graduated. This result suggests that the differences we observe at the three career points were points along a higher career long earnings trajectory for students that attended schools with better teachers.

The estimates of the impact of teacher quality on earnings of WLS respondents allow us to estimate the returns to local school district investments in teacher human capital using the private earnings differentials graduates received because of the community investments in their education. Using Census data from 1960-2000 to establish a baseline earnings profile for Wisconsin high school graduates, two equivalent calculations were calculated – the internal rate of return earned on a standard deviation investment in teacher human capital and the net present value of the investment using a 5 percent discount rate. Our preferred estimates suggested the rate of return on additional investments in teacher humans capital were in the 18-19 percent. This suggests local taxpayers were under-investing in their children’s education. Reasons for this deserve further investigation.

We believe our estimates reflect a causal effect of school resources on the later earnings of 1957 male Wisconsin high school graduates. Schools and education has changed since 1957. Thus, we certainly cannot say with any confidence that these estimates of teacher human capital on student earnings would correspond to the effects of investing these resources in students in later decades. There are important differences between Wisconsin schools in the 1950s and public schools today. One notable difference is the role of unions and collective bargaining by teachers. Teachers in Wisconsin did not gain the right to bargain with their school districts until the 1960s. In addition the tenure distribution of teachers in Wisconsin has changed significantly since the 1950s. In our data the mean years of teaching experience across districts was 4.4 years. In contrast, over the 1994-95 thru the 2009-2010 school years the average Wisconsin teacher had 12.4 years of experience.[33] While teachers in Wisconsin in the 1950s were paid based on their education and experience, the pay systems of these districts predates the education by teaching experience salary grid that became common in Wisconsin in later years and that precisely defined the salary of a teacher. Although recent research using matched teacher-student data discussed earlier shows teacher education and experience is not related to the earnings of students in their 20s, except for very inexperienced teachers, whether the results reported here that show very large returns to school quality generalize to investments in school quality today is now unknowable. This, however, is a shortcoming of any study that seeks to study the career long impact of any kind of educational policy; researchers must wait until the students receiving the inputs have finished their careers and have been followed over their entire careers. The WLS is a unique dataset with these qualities for one cohort of students.

[33] These estimates are based on tabulations by the authors using the publicly available individual level teacher data files from the Wisconsin Department of Public Instruction (www.dpi.wi.gov).

References

Aaronson, Daniel, Lisa Barrow, and William Sander. 2007. “Teachers and Student Achievement in the Chicago Public High Schools”. *Journal of Labor Economics* 25 (1): 95–135.

Altonji, Joseph G., and Thomas A. Dunn. 1996. “Using Siblings to Estimate the Effect of School Quality on Wages.” *Review of Economics and Statistics* 78: 665–671.

Becker, Gary S. 1964. *Human Capital: A Theoretical and Empirical Analysis.* New York: Columbia University Press.

Becker, Gary S. 1975. “Human Capital and the Personal Distribution of Income: An Analytic Approach.” In *Human Capital*, 2nd edition. New York: Columbia University Press.

Betts, Julian R. 1996. “Do School Resources Matter Only for Older Workers?” *Review of Economics and Statistics* 78: 638–652.

Boyd, Donald, Hamilton Lankford, Susanna Loeb, and James Wyckoff. 2005. “Explaining the Short Careers of High-achieving Teachers in Schools with Low-performing Students”. *The American Economic Review* 95 (2): 166–71.

Buddin , Richard and Gema Zamarro. 2009. “Teacher qualifications and student achievement in urban elementary schools**.”** *Journal of Urban Economics* 66(2): 103-115.

Card, David, and Alan B. Krueger. 1992. “Does School Quality Matter? Returns to Education and the Characteristics of Public Schools in the United States.” *Journal of Political Economy* 100: 1–40.

Chetty, Raj, John N Friedman and Jonah E. Rockoff. 2010a. “Measuring the Impact of Teachers I: Evaluating Bias in Tracher Value-added Estimates.” *American Economic Review* xxx: 1-42.

Chetty, Raj, John N Friedman and Jonah E. Rockoff. 2010b. “Teacher Value Added and Student Outcomes in Adulthood.” *American Economic Review* xxx: 1-46.

Coleman, James S., and et al. 1966. “Equality of Educational Opportunity.” U.S. Department of Health, Education and Welfare.

Goldhaber, Dan. 2007. “Everyone's Doing It, but What Does Teacher Testing Tell Us About Teacher Effectiveness?” *The Journal of Human Resources* 42 (4): 765–94.

Grogger, Jeff. 1996. “School Expenditures and Post-Schooling Earnings: Evidence from High School and Beyond.” *Journal of Economics and Statistics* 78: 628–637.

Hanushek, Eric A. 1986. “The Economics of Schooling: Production and Efficiency in Public Schools.” *Journal of Economic Literature* 24: 1141–1177.

Hanushek, Eric A., Steven G. Rivkin, and Lori L. Taylor. 1996. “Aggregation and Estimated Effects of School Resources.” *Review of Economics and Statistics* 78: 611–627.

Hanushek, Eric A. 2011. “The Economic Value of Higher Teacher Quality.” *Economics of Education Review* 30: 466-479.

Harris, Douglas N. & Tim R. Sass. 2011. “Teacher Training, Teacher quality and Student Achievement” Journal of Public Economics 95: 798-812.

Hauser, Robert M., William H. Sewell, and John Warren. 1984. “Education, Occupation and Earnings in the Long Run: Men and Women from Adolescence to Midlife.” Unpublished paper.

Hauser, Robert M., et al. 1993. “The Class of 1957 after 35 Years: Overview and Preliminary Findings.” Working Paper 93-17, Center for Demography and Ecology, University of Wisconsin–Madison.

Heckman, James, Anne Layne-Farrar, and Petra Todd. 1996a. “Human Capital Pricing Equations with an Application to Estimating the Effect of Schooling Quality on Earnings.” *Review of Economics and Statistics* 78: 562–610.

Heckman, James, Anne Layne-Farrar, and Petra Todd. 1996b. “Does Measured School Quality Really Matter? An Examination of the Earnings-Quality Relationship.” In *Does Money Matter? The Effect of School Resources on Student Achievement and Adult Success*, edited by G. Burtless. Washington DC: Brookings Institute.

Herd, Pamela, Deborah Carr, and Carol Roan. 2014. "Cohort Profile: Wisconsin Longitudinal Study (WLS)." International Journal of Epidemiology 43:34-41

Jacob, Brian A., and Lars Lefgren. 2004. “The Impact of Teacher Training on Student Achievement: Quasi-experimental Evidence from School Reform Efforts in Chicago”. *The Journal of Human Resources* 39 (1): 50–79.

Jacob, Brian A., and Lars Lefgren. 2008. “Can Principals Identify Effective Teachers? Evidence on Subjective Performance Evaluation in Education”. *Journal of Labor Economics* 26 (1): 101–36.

Loeb, Susanna, and John Bound. 1996. “The Effect of Measured School Inputs on Academic Achievement: Evidence from the 1920s, 1930s and 1940s Birth Cohorts.” *Review of Economics and Statistics* 78: 653–664.

Lubotsky, Darren, and Martin Wittenberg. 2006. “Interpretation of Regressions with Multiple Proxies”. *The Review of Economics and Statistics* 88 (3): 549–62.

Olson, Craig A. & Deena Ackerman. 2000. “High School Inputs and Labor Market Outcomes for Male Workers in Their Mid-thirties: New Data and New Estimates From Wisconsin.” IRP Working Paper 1205-00, University of Wisconsin-Madison.

Rivkin, Steven G., Eric A. Hanushek, and John F. Kain. 2005. “Teachers, Schools, and Academic Achievement”. *Econometrica* 73 (2): 417–58.

Ruggles, Steven J., Trent Alexander, Katie Genadek, Ronald Goeken, Matthew B. Schroeder, and Matthew Sobek. Integrated Public Use Microdata Series: Version 2.0 [Machine-readable database]. Minneapolis: University of Minnesota, 1997.

Ruggles, Steven J., Trent Alexander, Katie Genadek, Ronald Goeken, Matthew B. Schroeder, and Matthew Sobek. Integrated Public Use Microdata Series: Version 5.0 [Machine-readable database]. Minneapolis: University of Minnesota, 2010.

Schanzenbach, Diane Whitmore. 2006/2007. “What Have Researchers Learned From Project STAR?.” *Brookings Papers on Education Policy*, no. 9. Brookings Institution Press: 205–28.

Herd, Pamela, Deborah Carr, and Carol Roan. 2014. "Cohort Profile: Wisconsin Longitudinal Study (WLS)." International Journal of Epidemiology 43:34-41

Sewell, William H., and Robert M. Hauser. 1975. *Education, Occupation, and Earnings. Achievement in the Early Career*. New York: Academic Press.

Sewell, William H., and Robert M. Hauser. 1977. “The Class of 1957—Eighteen Years after Graduation from High School.” Center for Demography and Ecology, University of Wisconsin–Madison.

Wisconsin Longitudinal Study (WLS) [graduates, siblings, and spouses]: 1957-2012 Version 13.03. [machine-readable data file] / Hauser, Robert M., William H. Sewell, and Pamela Herd. [principal investigator(s)]. Madison, WI: University of Wisconsin-Madison, WLS. [distributor]; http://www.ssc.wisc.edu/wlsresearch/documentation/

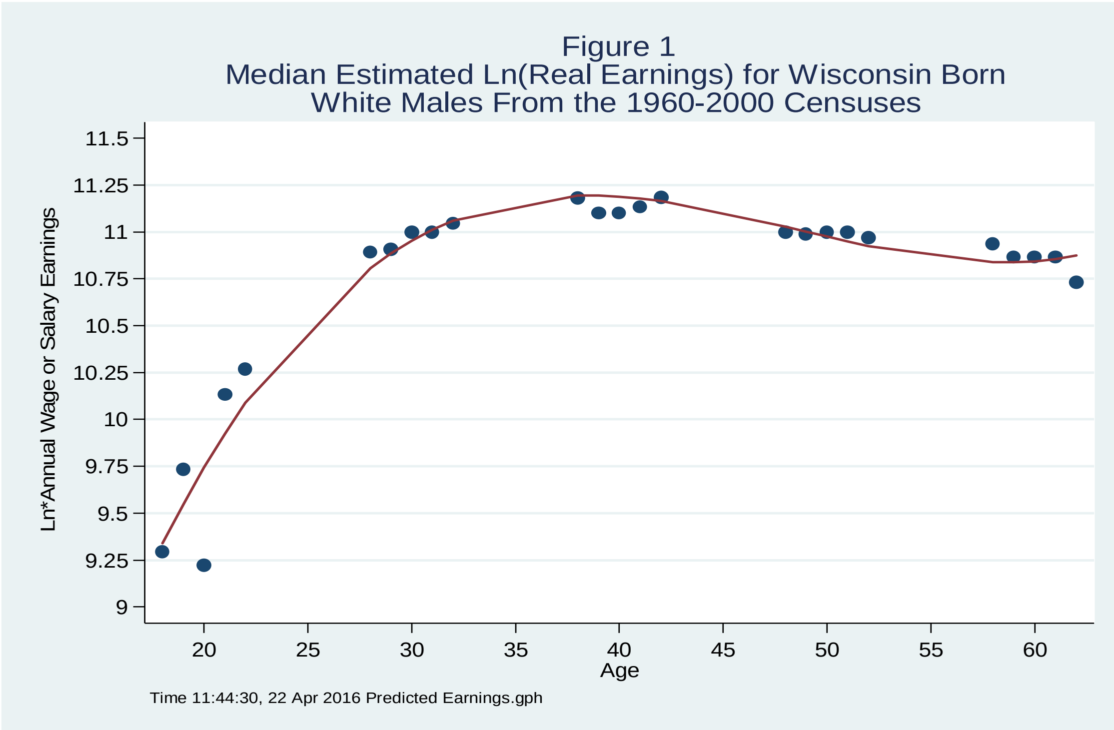

Figure 1
Median Estimated Ln(Real Earnings) for Wisconsin Born
White Males From the 1960-2000 Censuses
Ln*Annual Wage or Salary Earnings
11.5
11.25
11
10.75
10.5
10.25
10
9.75
9.5
9.25
9
20
25
30
35
40
45
50
55
60
Age
Time 11:44:30, 22 Apr 2016 Predicted Earnings.gph

Table 1
Variable Means and Standard Deviations
for Male Public School Respondents from Wisconsin Longitudinal Study of the Class of 1959[1]

Variable	Responded Any Year	Survey Year 1974	1992	2004
	Individual Level Variables			
Father's Education (Years)	9.805	9.829	9.882	10.011
	(3.369)	(3.771)	(3.368)	(3.502)
Mother's Education (Years)	10.633	10.609	10.694	10.761
	(2.753)	(2.767)	(2.732)	(2.749)
Mean Family Income '57-61	465.410	465.911	473.436	486.252
($100 of Income, $2010)	(416.732)	(414.393)	(423.017)	(549.226)
Grew Up on a Farm (%)	0.232	0.214	0.217	0.238
	(.)	(.)	(.)	(.)
Siblings (number of)	3.079	3.085	3.049	3.018
	(2.484)	(2.485)	(2.478)	(2.374)
Both parents in household (0/1)	0.937	0.938	0.938	0.927
	(.)	(.)	(.)	(.)
Annual Wage and Salary Income		69.148	81.714	57.561
(1000s of $2010)		(35.417)	(68.184)	(67.281)
Number of Respondents	3,194	2,608	2,283	920
	School District Level Variables			
Length of School Year	176	176	176	177
(days)	(3.000)	(3.000)	(3.000)	(3.000)
Fraction of teachers with	0.237	0.237	0.238	0.250
>4 yrs post-HS ed.	(0.173)	(0.174)	(0.174)	(0.179)
Mean years of teaching	5.975	5.982	5.998	6.103
experience	(1.439)	(1.438)	(1.425)	(1.391)
Mean years of teacher tenure	4.432	4.444	4.456	4.573
in district	(1.712)	(1.711)	(1.711)	(1.737)
Mean teacher salary, 1954-57	33,242	33,241	33,266	33,562
(2010 $)	(3,508)	(3,521)	(3,533)	(3,617)
Pupil/Teacher ratio	20.191	20.200	20.212	20.681
	(3.052)	(3.055)	(3.059)	(2.820)
High School offers college prep curriculum (%)	0.582	0.583	0.600	0.624
Number of seniors in district	80	81	79	91
	(83)	(83)	(82)	(90)
Number of school districts	280	278	275	226

[1] Sample restricted to nonfarmers with positive earnings reported in sample year. The sample was also restricted to individuals who received most of their income from wages or salaries. District-level variables weight each represented district equally.

Table 2a

Alternative OLS Models of the Effect of School-Level Inputs on Log Real Earnings

WLS Sample 1974

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Father's Education	0.0098***	0.0112***	0.0116***	0.0102***	0.0107***	0.0100***	0.0103***
(Years)	(0.0025)	(0.0025)	(0.0026)	(0.0025)	(0.0025)	(0.0025)	(0.0025)
Mother's Education (yrs)	0.0051	0.0056*	0.0051	0.0052	0.0054*	0.0053*	0.0055*
(Years)	(0.0032)	(0.0032)	(0.0032)	(0.0031)	(0.0032)	(0.0031)	(0.0032)
Ln(Family Income 57-61)	0.0756***	0.0910***	0.0995***	0.0793***	0.0854***	0.0799***	0.0776***
($100 in $2010)	(0.0135)	(0.0131)	(0.0134)	(0.0131)	(0.0133)	(0.0135)	(0.0136)
Length of School Year	0.0010	0.0067***					
(Days)	(0.0025)	(0.0021)					
Pupil/Teacher Ratio	-0.0029		0.0028				
	(0.0042)		(0.0046)				
Mean Years of Teaching	0.0337*			0.0326***			
Experience	(0.0184)			(0.0075)			
Mean Years of Teacher Tenure	-0.0164				0.0203***		
in District	(0.0109)				(0.0056)		
Fraction of Teachers with	0.1201*					0.2156***	
>=4 yrs post-HS ed.	(0.0723)					(0.0414)	
Mean Teacher Salary, 1954-57	0.0014						0.0088***
($1000s in 2010 dollars)	(0.0042)						(0.0019)
Constant	10.0984***	9.1466***	10.2326***	10.1946***	10.2649***	10.3387***	10.1065***
	(0.4256)	(0.3800)	(0.1192)	(0.0830)	(0.0768)	(0.0750)	(0.0843)
R-squared	0.0608	0.0510	0.0473	0.0579	0.0538	0.0580	0.0568

N=2608. Robust standard errors in parentheses are cluster at the district level.

*** p<0.01, ** p<0.05, * p<0.1

Table 2b

Alternative OLS Models of the Effect of School-Level Inputs on Log Real Earnings

WLS Sample 1992

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Father's Education	0.0227***	0.0242***	0.0242***	0.0227***	0.0231***	0.0230***	0.0232***
(Years)	(0.0050)	(0.0051)	(0.0051)	(0.0050)	(0.0050)	(0.0050)	(0.0049)
Mother's Education (yrs)	0.0180***	0.0182***	0.0184***	0.0182***	0.0186***	0.0182***	0.0184***
(Years)	(0.0061)	(0.0062)	(0.0062)	(0.0061)	(0.0061)	(0.0062)	(0.0062)
Ln(Family Income 57-61)	0.0988***	0.1143***	0.1146***	0.0957***	0.0990***	0.1010***	0.1006***
($100 in $2010)	(0.0228)	(0.0210)	(0.0210)	(0.0223)	(0.0220)	(0.0220)	(0.0227)
Length of School Year	-0.0031	0.0026					
(Days)	(0.0053)	(0.0041)					
Pupil/Teacher Ratio	-0.0001		0.0072				
	(0.0062)		(0.0057)				
Mean Years of Teaching	0.0370*			0.0366***			
Experience	(0.0213)			(0.0097)			
Mean Years of Teacher Tenure	0.0076				0.0263***		
in District	(0.0128)				(0.0073)		
Fraction of Teachers with	0.0730					0.1843***	
>=4 yrs post-HS ed.	(0.1363)					(0.0621)	
Mean Teacher Salary, 1954-57	-0.0046						0.0071**
($1000s in 2010 dollars)	(0.0074)						(0.0030)
Constant	10.4654***	9.4920***	9.8011***	9.8294***	9.9076***	9.9810***	9.7900***
	(0.8561)	(0.7025)	(0.1525)	(0.1228)	(0.1215)	(0.1228)	(0.1347)
R-squared	0.0553	0.0496	0.0500	0.0546	0.0537	0.0524	0.0518

N=2283. Robust standard errors in parentheses are cluster at the district level.

*** p<0.01, ** p<0.05, * p<0.1

Table 2c
Alternative OLS Models of the Effect of School-Level Inputs on Log Real Earnings
WLS Sample 2004

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Father's Education	0.0341***	0.0378***	0.0374***	0.0357***	0.0359***	0.0348***	0.0357***
(Years)	(0.0101)	(0.0100)	(0.0101)	(0.0102)	(0.0102)	(0.0101)	(0.0101)
Mother's Education (yrs)	0.0236*	0.0218*	0.0223*	0.0220*	0.0227*	0.0229*	0.0230*
(Years)	(0.0129)	(0.0130)	(0.0130)	(0.0128)	(0.0129)	(0.0127)	(0.0128)
Ln(Family Income 57-61)	0.0727	0.1004*	0.0954*	0.0815	0.0818	0.0711	0.0727
($100 in $2010)	(0.0563)	(0.0531)	(0.0535)	(0.0551)	(0.0545)	(0.0554)	(0.0564)
Partly Retired	-1.1951***	-1.2015***	-1.2010***	-1.1988***	-1.1980***	-1.1968***	-1.1971***
	(0.0681)	(0.0683)	(0.0682)	(0.0677)	(0.0679)	(0.0675)	(0.0674)
Length of School Year	-0.0142	-0.0009					
(Days)	(0.0092)	(0.0083)					
Pupil/Teacher Ratio	0.0031		0.0091				
	(0.0143)		(0.0140)				
Mean Years of Teaching	-0.0208			0.0339			
Experience	(0.0498)			(0.0209)			
Mean Years of Teacher Tenure	0.0075				0.0276*		
in District	(0.0337)				(0.0163)		
Fraction of Teachers with	0.3746					0.3228**	
>=4 yrs post-HS ed.	(0.2491)					(0.1276)	
Mean Teacher Salary, 1954-57	0.0072						0.0113**
($1000s in 2010 dollars)	(0.0122)						(0.0050)
Constant	12.0092***	9.8352***	9.5021***	9.5634***	9.6315***	9.7375***	9.4228***
	(1.5593)	(1.4770)	(0.4333)	(0.3390)	(0.3383)	(0.3388)	(0.3548)
R-squared	0.2735	0.2689	0.2692	0.2703	0.2704	0.2719	0.2709

N=920. Robust standard errors in parentheses are cluster at the district level.
*** p<0.01, ** p<0.05, * p<0.1

Table 3
Key Estimated Coefficients and
P-values for Joint Tests Across Time Periods on Interaction
Terms between Time and Teacher Human Capital Measures

A: Models with a Single Teacher Human Capital Measure

	(1) Total Experience	(2) District Tenure	(3) Teacher Education	(4) Teacher Salary
Coeffficient in	0.0345***	0.0238***	0.2205***	0.0085***
Constrained Regressions	(0.0068)	(0.0059)	(0.0510)	(0.0022)
$\beta_{Q*1992} = \beta_{Q*2004} = 0$	0.927	0.717	0.64	0.735
$\beta_{Q*1992} = \beta_{Q*2004}$	0.915	0.943	0.376	0.549
$\beta_{Q*1992} = 0$	0.698	0.430	0.635	0.549
$\beta_{Q*2004} = 0$	0.957	0.702	0.500	0.721

B: Models with all Four Teacher Human Capital Measures

	(5) Total Experience	(6) District Tenure	(7) Teacher Education	(8) Teacher Salary
Coeffficient in	0.0269	-0.0036	0.1373	-0.0015
Constrained Regressions	(0.0171)	(0.0122)	(0.0947)	(0.0046)
$\beta_{Q*1992} = \beta_{Q*2004} = 0$	0.618	0.209	0.626	0.402
$\beta_{Q*1992} = \beta_{Q*2004}$	0.329	0.992	0.34	0.627
$\beta_{Q*1992} = 0$	0.836	0.078	0.686	0.183
$\beta_{Q*2004} = 0$	0.392	0.53	0.433	0.946

Table 4
OLS Estimates of the Effect of School Characteristics on Mean Teacher Salaries[1]
for Wisconsin School Districts, 1995-57

Variable	(1)	(2)
Mean Years of Teaching Experience	0.4398*	0.4110**
	(0.2357)	(0.2059)
Mean Years of Teacher Tenure in District	0.4542**	0.3217*
	(0.2178)	(0.1847)
Fraction of Teachers with post-Bachelors	9.6689***	7.7813***
Exoerience	(1.0596)	(1.0335)
Pupil/Teacher ratio		0.0891
		(0.0540)
Length of School Year (days)		0.2645***
		(0.0493)
North Central Region of WI		-0.0555
		(0.4888)
Northeast Region of WI		-0.2971
		(0.4945)
Southwest Region of WI		0.2744
		(0.4237)
Southeast Region of WI		0.8732**
		(0.3852)
Constant	26.3129***	-21.2803**
	(0.7205)	(8.5472)
R^2	0.5973	0.6642

[1] Estimated effect is per $1,000 of salary; all dollar amounts are in $2010. N=280
*** p<0.01, ** p<0.05, * p<0.1 Robust standard errors are reported in parentheses
We don't know what is in 3, but I think it has fewer controls.

Table 5

OLS Estimates of Mean Teacher Salary and Decompositions of Mean Teacher Salary on Ln(Real Earnings) of WLS Students in 1974, 1992 and 2004

	Predicted Teacher Salary From Table 4 Estimates			
	Table 4, Column 1	Table 4, Column 2	Only coef on 3 tcher HC variables, Table 4, Column 2	Mean Teacher Salary
Varriable or statistic	(1)	(2)	(3)	(4)
$\widehat{Salary}_i$	0.0157***	0.0116***	0.0186***	0.0085***
	(0.0035)	(0.0033)	(0.0044)	(0.0022)
Teacher salary residual	-0.0012	0.0031	0.0010	
	(0.0045)	(0.0049)	(0.0050)	
R^2	0.2559	0.2551	0.256	0.2548
$(e^{\beta}-1)*100$ (implied effect %)	1.58	1.17	1.89	0.85
Impact of a SD change in teacher HC on annual earnings (%)	4.35	3.37	4.18	3.03
(SD in parentheses: $1000)	(2.711)	(2.855)	(2.200)	(3.508)

N=5811

*** p<0.01, ** p<0.05, * p<0.1

Standard errors are clustered at the individual level.

In column 1 $Salary_i = .440*TchExp_i + .454*TchTenure_i + 9.669*TchEduc_i$

In column 2 $Salary_i$ = .411*TchExpi + .322*TchTenurei +7.781*TchEduci + .089*$Pupil/Tch_i$ +.265*$SchYr_i$ - .056*$NorthCentral_i$ -.297*$Northeast_i$ + .274*$Southwest_i$ + .873*$Southeast_i$

In column 3 $Salary_i$ = .411*TchExpi + .322*TchTenurei +7.781*TchEduci

Table 6

Collected Coeffiicents and P-values from Estimates of the Effect of Teacher Human Capital on Earnings Using Alternative Specifications

	Teacher Salary Variable From Table 4			
	Table 4, Column 1	Table 4, Column 2	Only coef on 3 tcher HC variables, Table 4, Column 2	Mean Teacher Salary
Underlying Model Specification	(1)	(2)	(3)	(4)
1 p-value for test of hypothesis that RE & FE coef on family background variables are equal where the RE model includes predicted teacher salary[1]	0.831	0.596	0.595	0.839
2 Coefficients From Table 5 on Teacher salary variable	0.0157***	0.0116***	0.0186***	0.0085***
	(0.0035)	(0.0032)	(0.0044)	(0.0022)
3 With Additional family & School Controls	0.0158***	0 .0120***	0.0191***	0.0081***
	(0.0036)	(0.0033)	(0.0045)	(0.0023)
With Additional family & School Controls plus:				
4 High school size, region, urban, milwaukee, greater Milwaukee indicators, region indicators	0.0148**	0.0115**	0.0187***	0.0073*
	(0.0053)	(0.0054)	(0.0064)	(0.0042)
5 Additional family and school controls plus county indicators (70 counties)	0.0168***	0.0139**	0.0206***	0.0096**
	(0.0050)	(0.0051)	(0.0062)	(0.0041)
Alternate Samples				
6 Restricted to non-Milwaukee respondents	0.0168***	0.0132***	0.0204***	0.0093***
	(0.0038)	(0.0036)	(0.0047)	(0.0026)
7 Restricted to districts with only one High School	0.0180***	0.0149***	0.0218***	0.0119***
	(0.0041)	(0.0041)	(0.0051)	(0.0032)

*** p<0.01, ** p<0.05, * p<0.1

Standard errors are clustered at the individual level.

[1] The predicted salary variable used in each column is the same as those used in Table 5.

Table 7
Estimates Using Alternative Samples and Definitions of Earnings

Sample & Earnings Measures	Teacher Salary Variable From Table 4			
	Table 4, Column 1	Table 4, Column 2	Only coef on 3 tcher HC variables, Table 4, Column 2	Mean Teacher Salary
	(1)	(2)	(3)	(4)
1 ln(wage or salary income>0) &	0.0157***	0.0116***	0.0186***	0.0085***
Major source of income (Table 5)	(0.0035)	(0.0032)	(0.0044)	(0.0022)
2 ln(wage or salary income gt 0)	0.0171***	0.0130***	0.0204***	0.0094***
& not completely retired	(0.0035)	(0.0032)	(0.0044)	(0.0022)
N=5826				
3 wage or salary income ge 0	1275***	1079***	1588***	730***
& not completely retired	(302)	(271)	(371)	(193)
Estimate/Mean	0.0188	0.0159	0.0234	0.0107
N=6189	(0.0044)	(0.0040)	(0.0055)	(0.0028)
4 ln(∑ (wage/salary, self-emplyed	0.0123***	0.0094***	0.0147***	0.0078***
farm income) gt 0)	(0.0037)	(0.0033)	(0.0045)	(0.0023)
N=6092				

*** p<0.01, ** p<0.05, * p<0.1
Standard errors are clustered at the individual level.

Table 8
Estimates of the Impact of High School Teacher Human Capital on Assets Owned
In 2004 When Respondents were About 64 Years Old

	Teacher Salary Variable From Table 4			Implied savings rate/yr	
		Only coef on			
WLS Respondent Outcome Measures	Table 4, Column 2	3 tcher HC variables, Table 4, Column 2	Mean Teacher Salary	Real return 90 day Tbill	Real (S&P 500 returns-1% fees)
($2004)	(1)	(2)	(3)	(4)	(5)
1. Own and spouse estimated net worth	20,805**	23,825**	3,482	27.8	3.5
(N=2137)	(9,572)	(11,975)	(6,306)		
2. Estimated home equity	5,276***	6,655***	2,069	7.8	1.0
(N=1954)	(1,495)	(1,867)	(931)		
3. Own and spouse estimated net worth	16,325*	18,181	2,545	21.2	2.7
less Estimated home equity	(9,087)	(11,332)	(5,986)		
(N=2084)					
4. Own and spouse retirement investments	10,551***	13,340***	5,863***	15.7	2.0
(N=1776)	(2,541)	(3,219)	(1,844)		

*** p<0.01, ** p<0.05, * p<0.1
Robust errors are in parentheses.

Table 9

Estimated Internal Rates of Return and Net Present Values From Estimated Investments in Teacher Human Capital and Earning Returns of Graduates

Treatments and Outcomes	Predicted Value of Teacher HC From Full Teacher Salary Model	
	(1)	(2)
Estimated effect of $1000 ($2010) of HC Investment	1.86	2.18
SD in the treatment ($1000s)	2.20	2.20
Teacher HC differential/Student/year ($2010)[1]	108.96	108.96
Grades 1-12 investments		
Internal rate of return (%)	18.1	19.0
Net Present Value ($)	15,898	18,870
Grades 9-12 investments		
Internal rate of return (%)	34.5	36.2
Net Present Value ($)	24,530	28,920
Sum of undiscounted earnings differential	101417	119287
Sum of discounted (to grade 1) earnings differential (5%)	16,864	19,836
NPV of an additional $1 invested/student over:[2]		
Grades 1-12 ($)	16.11	19.05
Grades 9-12 ($)	62.18	73.05

1. assumes pupil/teacher ratio=20.19.

2. The amount invested per student per year such that the present value of the investments equals $1 is $0.282 over 4 years and $0.113 over 12 years.