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INFORMATION EXTERNALITIES AND THE SOCIAL PAYOFF TO ACADEMIC ACHIEVEMENT

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Abstract

The thesis of this paper is that wage rates and earnings give misleading signals to public and private decision makers regarding the social benefits of certain kinds of education and training (E&T) investments. The misleading signals are a result of the fact that (1) workers and employers prefer employment contracts which either do not recognize or only partially recognize differences in productivity among workers doing the same job and (2) important dimensions of E&T accomplishment -- the skill, knowledge and competencies actually developed -- are often not signaled to potential employers and therefore have limited influence on the allocation of workers to jobs. The result is that there are significant productivity differentials between workers who receive the same pay for the same job and some of these productivity differentials are related to dimensions of E&T accomplishment that are not efficiently signaled.

The paper develops a very simple signaling/implicit contracting model of the labor market. True productivity depends on general intellectual achievement (GIA) and educational credentials but GIA is unobservable, so pay is based on credentials and supervisory assessments of doubtful reliability. As in most signaling models, the labor market tends to overcompensate credentials and undercompensate academic achievement. The next section of the paper refutes the simple wage equals individual MRP assumption by presenting evidence of great variability of productivity across workers paid the same wage and doing the same job. The paper then tests and rejects a weaker hypothesis that can justify an inference that productivity and wage effects of GIA are equal -- namely that deviations of productivity from wages are not correlated with academic achievement. Finally the paper develops a method of estimating the true impact of academic achievement on productivity and applies it to data on the productivity of 31,399 workers.

The analysis provides strong support for signaling theory. As predicted by the theory when workers doing the same job are compared and academic achievement (the unobservable) is controlled, the years of schooling signal is negatively associated with relative productivity. When the schooling signal is controlled, academic achievement has a very strong positive effect on relative productivity. This implies that academic achievement has a larger effect on productivity than it has on wages. Academic achievement produces some private rewards for it facilitates entry into higher paying occupations and promotions into better jobs. These are the effects that are captured by standard wage regressions. In addition GIA has effects not picked up by wage regressions. In each job the individual works he/she is doing a better than average job but not receiving an appreciably higher wage as a result. The results imply that schooling raises productivity primarily by improving academic achievement as it is measured by standard tests. When it does not lead to gains on such tests, the credentials that graduates receive tend to be overcompensated. The second major implication of the results is that academic achievement is substantially under compensated if it is not signaled to the market by a credential. This tendency to underreward academic achievement may help explain why American high school students devote less time and energy to learning than their counterparts abroad.

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The thesis of this paper is that wage rates and earnings give misleading signals to public and private decision makers regarding the social benefits of certain kinds of education and training (E&T) investments. The misleading signals are a result of the fact that (1) workers and employers prefer employment contracts which either do not recognize or only partially recognize differences in productivity among workers doing the same job and (2) important dimensions of E&T accomplishment -- the skill, knowledge and competencies actually developed -- are often not signaled to potential employers and therefore have limited influence on the allocation of workers to jobs. The result is that there are significant productivity differentials between workers who receive the same pay for the same job and some of these productivity differentials are related to dimensions of E&T accomplishment that are not efficiently signaled. Another consequence is that the private return to effort in school is considerably smaller than the social return to such effort. This in turn may help explain why American high school students devote less time to learning than their counterparts abroad.

I. The Puzzle: Why Are Labor Market Rewards for Academic Achievement in High School So Modest?

According to the National Commission on Excellence in Education:

> If only to keep and improve on the slim competitive edge we still retain in world markets, we must dedicate ourselves to the reform of our educa-tional system....Learning is the indispensable investment required for success in the "information age" we are entering. (p. 7).

Behind their call for higher standards and greater emphasis on academic subjects is the assumption that most jobs require (or soon will require) significant competency in communication, math and reasoning. To what extent does evidence from the labor market support this claim? Are the workers who have these competencies receiving higher wages?

When learning is efficiently signaled by a credential, the answer is an unqualified yes. In 1987 25 to 34 year old male (female) college graduates working full time full year earned 41 (48) percent more than comparable high school graduates and high school graduates earned 21 (23) percent more than high school dropouts. Good educational credentials are also associated with a higher probability of employment.

When learning is not signaled by a credential, the answer is also yes but a highly qualified yes. The labor market rewards for academic achievement (controlling for years of schooling) are modest and do not appear until many years after the completion of schooling. In Willis and Rosen's (1979) structural model of college attendance and earnings, for example, a one standard deviation increase in the math and reading scores of a high school graduate who did not to go to college lowered the first job's wage by 3.5 percent and raised the wage 25 years later by only 3.5 percent. Other data sets -- Project Talent, Class of 1972, NLS Youth -- yield similarly modest estimates of the private payoffs to academic achievement for those who do not go to college.[1]

Correcting the Willis and Rosen results for measurement error and the restricted range of the test score distribution increases the estimated effect of academic achievement to a modest 2 percent wage gain per grade level equivalent.[2] Consequently, the puzzle remains. Credentials have large effects on earnings even when good measures of what has been learned are included in the regression. Good measures of the skills and knowledge taught in school have small direct effects on earnings when credentials are controlled. One interpretation of this finding is that schooling develops or signals other economically productive talents such as discipline, occupationally specific skills and low propensities to quit (Weiss, 1988). A second interpretation is that signals of academic achievement have value even when actual achievement is absent because employers find it very difficult to measure actual achievement. Either way, it would appear that studying in school and substantially increasing one's achievement test scores yields only modest rewards if credentials do not certify the learning to the world.

Does this imply that the social returns to improvements in general academic achievement are equally small? This requires estimates of the productivity consequences of an increase in academic achievement. The standard approach to such a question is to infer the effect of academic achievement on productivity from its effects on wage rates. This inference is justified by an assumption that either individuals are paid their individual marginal revenue products or that discrepancies between wages and MRP are random. Are such assumptions justified? Can one conclude that if the wage effects of academic achievement are small, productivity effects are equally small?

The answer provided by the paper is no. The assumption that wages = MRP is shown to be invalid. Evidence is offered that there are large discrepancies between individual productivity (MRP_i) and individual wage rates, (W_i) and that many of these discrepancies are systematically related to academic achievement. This evidence is consistent with signaling and long term contracting theory and inconsistent with a perfect information auction model of employment contracts. The major empirical finding of the paper is that competencies measured by "aptitude" and broad spectrum achievement tests have considerably larger effects on productivity than on wage rates.

The paper is organized as follows: Section 2 of the paper develops a very simple signaling/implicit contracting model of the labor market. True productivity depends on general intellectual achievement (GIA) and educational credentials but GIA is unobservable, so pay is based on credentials and supervisory assessments of doubtful reliability. As in most signaling models, the labor market tends to overcompensate credentials and undercompensate academic achievement. Section 3 refutes the simple wage equals individual MRP assumption by presenting evidence of great variability of productivity across workers paid the same wage and doing the same job. Section 4 of the paper tests and rejects a weaker hypothesis that can justify an inference that productivity and wage effects of GIA are equal -- namely that deviations of productivity from wages are not correlated with academic achievement. The fifth section analyzes the effect of academic achievement and years of schooling on productivity relative to other occupants of the same job. Section 6 reviews evidence on the effect of schooling and relative productivity on within-job relative wage rates.

The analysis provides strong support for signaling theory. As predicted by the theory when workers doing the same job are compared and academic achievement (the unobservable) is controlled, the years of schooling signal is negatively associated with relative productivity. When the schooling signal is controlled, academic achievement has a very strong positive effect on productivity. This implies that academic achievement has a larger effect on productivity than it has on wages. Academic achievement generates private rewards primarily by enabling entry into better schools and by facilitating entry into higher paying occupations and promotions into better jobs. These are the effects that are captured by standard wage regressions. Academic achievement also has effects that are not picked up by a wage regression. In each job the individual works he/she is doing a better than average job but not receiving a comparably higher wage as a result. The empirical findings suggest that when academic achievement is not signaled to the labor market by a credential, it tends to be under compensated. Another implication is that if the adult test score/schooling correlation arises because of screening rather than learning, educational credentials are significantly overrewarded, particularly in blue collar, clerical and service jobs. The final section of the paper discusses the implications of these findings for growth accounting, for benefit cost analysis and for educational policy.

II. A Signaling/Implicit Contract Perspective on the Economic Rewards for Academic Achievement

There are a number of reasons why workers and employers may prefer employment contracts which do not pay individual workers their individual marginal product: the unreliability of the feasible measures of individual productivity (Hashimoto and Yu, 1980), risk aversion on the part of workers (Stiglitz, 1974), productivity differentials that are specific to the firm (Bishop, 1987), the desire to encourage coworker cooperation and prevent sabotage(Lazear 1986) and union preferences for pay structures which limit the power of supervisors. In addition, compensation for differences in job performance may be non-pecuniary -- praise from one's supervisor, more relaxed supervision, or a high rank in the firm's social hierarchy (R. Frank, 1984).

A study of how individual wage rates varied with job performance found that when people hired for the same or very similar jobs are compared, the elasticity of relative starting wage rates with respect to a ratio scale measure of relative productivity is no greater than .08 (Bishop, 1987a). After a year at the firm, the more productive workers were more likely to be promoted, but the elasticity of the relative wage with respect to reported productivity was still quite low. The elasticity was .2 in nonunion firms with about 20 employees and zero in unionized establishments with more than 100 employees and in nonunion establishments with more than 400 employees.

If relative wage rates only partially compensate the most capable workers in a job for their greater productivity, why don't they obtain promotions or switch to better paying firms? To some degree they do, and this explains why workers who score high on tests are both higher paid and more likely to be employed. But the sorting process is not completely effective because employers cannot accurately predict the future productivity of job applicants or current employees. In addition they usually lack information on "aptitude" test scores or grade point averages that would allow them to predict that component of an employee's productivity that is associated with academic achievement. While college transcripts are often requested and used by employers, most employers do not request high school transcripts. A 1987 survey of small and medium employers who were members of the National Federation of Independent Business found that only 14.2 percent obtained high school transcripts prior to hiring a high school graduate (Bishop and Griffen forthcoming). Malizio and Whitney's (1984) survey of large employers found that only a handful used high school transcripts to select which applicants to interview, and the majority never requested a transcript at any point in the hiring process. One of the primary reasons for this is that very few employer requests for transcripts are honored. Nationwide Insurance, for example, had over 1,200 job applicants sign requests for high school transcripts in 1982 and received only 93 responses. When the personnel officer asked school staff why transcripts were not forthcoming, he was told they were "too busy". A second reason why employers generally do not use high school transcripts to help make hiring selections is the hiring delays that would result. Schools are often tardy in responding to such requests. Employers, on the other hand, want to make a fast decision. They generally have little notice of openings. In only 23% of the hiring events sampled by the NCRVE employer survey (1982) did the employer have more than 2 weeks notice of the opening. The desire for speed results in 65 percent of job openings being filled within two weeks. Despite limited use of high school transcripts in selecting employees, employers believe that grade point averages are good predictors of future productivity. A policy capturing experiment with a nationwide sample of 750 employers found that employer ratings of completed job applications were more affected by high school grade point average than any other single worker characteristic (Hollenbeck and Smith, 1984).

Referrals by teachers, principals and counselors are another way in which information on academic achievement becomes available to employers. The teachers in occupationally specific programs often provide such referral services but most high school students are not in these programs. Only 3.5 percent of workers report their current job was obtained through the efforts of their school (Rosenfeld, 1975). Most teachers do not have the contacts necessary and do not view developing such contacts to be a part of their job description. Another reason why teacher referrals are uncommon and recommendation letters so bland is that recommenders take a risk if they commit anything negative to paper. The threat of damage suits by unsuccessful job applicants and the Federal Education Rights and Privacy Act have caused school staff to become extremely careful about what they divulge about students.

Tests are probably the best way to evaluate academic achievement. However, the Equal Employment Opportunity Commission's 1971 Guidelines on Employment Testing Procedures prohibit the use of a test on which minorities or women score below white males unless the employer can prove that the test is a valid predictor of performance on jobs at that firm. Each firm proposing to use a test had to do its own validity study separately on blacks and whites (29C.F.R.S607.5(b); Wigdor, 1982). Small firms found the costs prohibitive and did not have enough employees to do such a study. The firm also had to prove that no other test or selection method was available that was equally valid but had less adverse impact.

Since there are hundreds of potential selection methods with less adverse impact, the firm was potentially obligated to <u>prove</u> that all of these alternatives were less valid predictors of job performance than the one selected. These guidelines caused many firms to drop tests altogether, while other firms used the test only to screen out the bottom 10 or 20 percent of job applicants, rather than to select those with the highest scores (Friedman and Williams, 1982). The NFIB survey found that in 1987 only 2.9 percent of recently hired workers at these firms had completed an aptitude test as part of the application process.

Employers prohibited from using tests of general intellectual achievement (GIA) in their hiring decisions are likely to respond by giving greater weight to visible worker characteristics such as years of schooling which correlate highly with GIA.[3] The use of schooling as a screening device results in coworkers having very similar amounts of schooling. Only 20 to 25 percent of the total variance of schooling is within job variance. For test scores in contrast about 44 percent of the population variance is within job variance (Hunter and Hirsh, 1987). Wage regressions estimated in data sets affected by such a prohibition will probably yield higher schooling coefficients and lower test score coefficients.

Assume, for example, competitive labor markets, rational profit maximizing employers and a true relationship between productivity (P^t) and observable credentials (S) and unobservable GIA of the following form:

(1) $P^t = a_0 + a_1 GIA + a_2 S + u$

Twenty seven percent of the work force has less than one year of tenure (Horvath 1981). Lacking information on GIA, let us assume employers use regressions of measured productivity (P) on credentials (S) and interview performance (I) for previous new hires to develop rules for selecting new hires and setting initial compensation. General intellectual achievement is related to S and I by $GIA = g_o + g_1 S + g_2 I + v$ where GIA and I are defined in SD units, cov(Iu) = 0 and $g_2 < 1$. Thus, the wage function for new hires is:

(2) $W' = a_0 + a_1 g_o + (a_1 g_1 + a_2)S + a_1 g_2 I$

For workers with more than one year of tenure let us assume that compensation is set equal to a productivity expectation (P) that is based on credentials and a supervisory assessment (R). This supervisory assessment is an imperfect measure of a weighted average (P) of past productivity levels ($P_n, \ldots P_o$) calculated using weights, $w_t = (w_n, \ldots w_o)$.

$$(3) \quad R = P + \epsilon \qquad = \sum_{t=0}^{n} w_t P_t / \sum_{t=0}^{n} w_t \quad + \epsilon$$

The compensation schedule will be:

$$(4) \quad W'' = P_{n+1} = c_o + c_1 R + c_2 S$$

Supervisor ratings correlate only .6 with ratings made by another supervisor and .43 with work sample measures of job performance. Repeated measurement increases reliability only marginally (Hunter, 1983; King, Hunter and Schmidt, 1980). This means that the variance of ϵ is considerable. Hashimoto and Yu (1980) have examined optimal pay structures when the measure of productivity is unreliable and have demonstrated that the tendency to compensate higher productivity with higher pay diminishes with the decline in the reliability of the productivity measure. The coefficient on supervisory assessment (c_1) in the wage function for long term employees will consequently be considerably less than 1.[4]

Now enter an analyst whose assignment is to uncover the true relationship between schooling, GIA and productivity. For a large sample of workers the analyst collects data on wages, credentials and GIA (adult test scores) and estimates the following regression:

$$(5) \quad W = b_o + b_1 GIA + b_2 S$$

Since the aggregate wage function is some mix of (2) and (4), the resulting estimator b_1 will be smaller than the true effect, a_1, of test scores on productivity and the estimator b_2 will exaggerate the true effect of schooling net of adult test scores, a_2. These results correctly characterize the private payoffs to the two dimensions of schooling. However, they do not correctly characterize the pattern of social returns. An analyst who made the standard assumption that W=P would obtain downward biased estimates of the effect of academic achievement on productivity and upward biased estimates of the effect of credentials on productivity. The evidence supporting this assertion and the empirical relevance of signaling and implicit contracts theory is presented in the sections that follow.

III. Are There Important Discrepancies Between Wage Rates and Individual Marginal Revenue Products?

A direct test of $W_i = P_i$ and of whether wage equations yield biased estimates of GIA's effect on productivity will be presented. A good way to conduct the test is to sample workers who do the same job and are paid the same wage and measure their output directly. If output varies substantially in such samples, $W_i=P_i$ must be rejected.

A search for studies of output variability yielded 49 published and 8 unpublished papers covering 94 distinct jobs.[5] Their results are summarized in column 3 and 4 of Table 1 (a description of methods used to estimate CVs and the sources can be obtained from the author). For a great many occupations physical measures of output or gross sales data were the basis of these estimates of the standard deviation of productivity. The average ratio of the standard deviation of output to mean output, coefficient of variation or CV, was 63 percent for high level sales workers, 30 percent for sales clerks, 26 percent for clerical workers with decision making responsibilities, 16.7 percent for other clerical workers and 14 percent for hourly paid semi skilled factory workers. For other occupations estimates of output variability were obtained from managers and industrial engineers who supervise individuals in the occupation. The average CV was 36 percent for technical jobs, 33 percent for managerial jobs and 27 percent for craft workers other than foreman and plant operators.

When a firm expands by hiring extra workers, it incurs significant fixed costs. It must rent space, buy equipment, hire supervisors and recruit, hire, train, and payroll the additional production workers. If output can be increased by hiring more competent workers, all of these costs can be avoided and the firm's capital becomes more productive. These factors tend to magnify the effects of work force quality on productivity. They imply that the ratio of the standard deviation of worker productivity in dollars (SD$) to average worker compensation is much larger than the productivity CV for that job (Klein, Spady and Weiss 1983; Frank 1984).

Estimates of productivity standard deviations (SD$) in 1985 dollars are reported in column 4 of the table. In many cases the original study of output variability made no attempt to estimate SD$'s, so the estimate has been calculated from the CV. The estimates of SD$ were derived as a product of the CV, the mean compensation for that job and the ratio of value added to compensation for that industry (for manufacturing as a whole this ratio is 1.63). The value added to compensation ratio in retailing and in real estate was much too high to be used as an adjustment factor. So for all sales occupations it was assumed that SD$ = CV times average compensation. Except for the higher level sales personnel and one of the administrative jobs, these workers were not paid commissions or bonuses keyed to productivity.

While specific estimates of SD$ can be debated, one would have to take the extreme view that SD$ is almost zero before the basic conclusion that workers paid the same wage are often significantly different in productivity would change. This implies that the $W_i \equiv P_i$ assumption cannot possibly be true.

IV. Are Discrepancies Between Wage Rates and MRP Positively Correlated With Academic Achievement?

There is, however, a weaker assumption that would make the standard wage equation an unbiased estimator of GIA's impact on productivity, namely:

(6) $W_i = E(P_i|GIA_i,S_i,X_i)$. where i indexes individuals

This also is testable in data containing measures of P, GIA, S and other characteristics of the worker such as gender, ethnicity and experience (X) for people doing the same job and paid the same wage. If employers know GIA and adjust pay accordingly, then in samples of workers paid the same wage there should be no significant correlation between GIA and P conditional on S and X. It is possible to test this hypotheses, for industrial psychologists have conducted literally hundreds of studies (covering hundreds of thousands of workers) of GIA's association with relative productivity in samples of job incumbents. Most of these studies have been conducted in samples of workers whose hourly wage depended on seniority and not performance.

The first column of Table 1 presents average correlations between GIA tests and supervisory ratings of job performance from Ghiselli's (1973) comprehensive review of published and unpublished studies of the validity of GIA tests.[6] The second column of the table presents correlations from the GATB Manual (Department of Labor, 1970) and from other recent meta analysis. Clearly there is a significant positive correlation between GIA test scores and job performance in a great variety of jobs. The strength of the association is apparently related to the cognitive demands of the job, for the raw validities are higher for white collar and skilled blue collar jobs than for semiskilled factory work, transportation equipment operatives and retail sales clerks. Analysis of data sets which have better measures of job performance (work sample measures rather than supervisory ratings) find even stronger relationships between GIA and job performance (Hunter, 1983). Except for sales representatives, and a few jobs where pay is affected by supervisory ratings, there was minimal variation of wages in these samples not related to seniority.

In summary, there is considerable evidence that workers who do the same job at a firm and are paid a wage that depends on seniority only, are often quite different in productivity and these differences in productivity are often correlated with the employee's measured academic achievement. These two results imply that GIA has larger effects on productivity than on wage rates. A method of measuring the effect of GIA and years of schooling on the discrepancy between a worker's productivity and his or her wage will now be described.

V. The Effect of Academic Achievement on a Worker's Productivity Relative to Coworkers

Absolute measures of individual productivity that are comparable across jobs and across people occupying a job are impossible to obtain, so it is never going to be possible to directly estimate equation 1 in representative samples of the nation's workers. Wage data is available for random samples of workers, but the parameters obtained from estimating equation 5 are biased representations of the true relationship between productivity and its determinants. How then can unbiased estimates of equation 1 be obtained? Measures of relative productivity are often available for workers in specific jobs, so fixed effects estimation of equation 1 [where narrowly defined jobs but not individuals have fixed effects on productivity] is one approach that might be tried. Since, however, individuals are (1) selected for these jobs on the basis of unobservable characteristics correlated with GIA and schooling and (2) are retained or fired on the basis of realized productivity outcomes, selectivity problems may bias estimations of equation 1 which allow for job-specific fixed effects even if the jobs studied are randomly selected.

This paper takes a different approach. The objective is an estimate of a model that is only minimally biased by selection problems that predicts the difference between the true productivity, P_{ij}, of the i^{th} worker in the j^{th} job and that individual's wage, W_{ij}. Models predicting a proxy for this discrepancy are estimated in a data set which is as representative as possible of the full range of jobs in the economy, thus selection bias is minimized. A second advantage of this approach is that it yields direct tests of the key predictions of signaling theory when schooling is a signal for GIA: P_{ij}-W_{ij} is positively related to GIA and negatively related to schooling when GIA is controlled. Since the null hypothesis is that the coefficients on these variables are zero, the crucial hypothesis tests are not hostage to potentially controversial assumptions about the scaling of the discrepancy variable.[7] The relationship between true productivity, P_{ij}, and that individual's wage, W_{ij} is given by the following identity:

$$(7)\quad P_{ij} \equiv W_{ij} + (P_{ij}-P_j) - (W_{ij}-W_j) + (P_j-W_j)$$

Assume that each of the terms on the right hand side of this identity has been modeled in representative samples of the population as a function of $\underline{Z}_{ij}$, a vector of worker characteristics--GIA, schooling, experience, gender, race, etc.:

$$(5')\quad W_{ij} = \underline{Z}_{ij}\underline{\beta}_1$$

$$(8)\quad P_{ij}-P_j = \underline{Z}_{ij}\underline{\beta}_2$$

$$(9)\quad W_{ij}-W_j = \underline{Z}_{ij}\underline{\beta}_3$$

$$(10)\quad P_j-W_j = \underline{Z}_{ij}\underline{\beta}_4$$

If all four dependent variables have the same metric, an estimate of the determinants of true productivity can be obtained simply by summing these four equations.

$$(1')\quad P_{ij} = \underline{Z}_{ij}\underline{a} = \underline{Z}_{ij}(\underline{\beta}_1 + \underline{\beta}_2 + \underline{\beta}_3 + \underline{\beta}_4)$$

The first of the four equations is the standard wage function. Equation (8) predicts the worker"s "relative productivity", the deviation of the "i"th worker's marginal revenue product net of current required training costs (P_{ij}) from the marginal revenue product net of training costs (P_j) of the average incumbent in the "j"th job at the firm. Evidence on how relative productivity is related to worker characteristics is presented below. Equation (9) predicts the worker's "within-job relative wage", the deviation of an individual's wage from the mean for that job at the firm. Evidence on how the within-job relative wage relates to worker characteristics is presented in section 6. Equation (10) predicts the difference between the marginal revenue product net of current required training costs of the <u>average</u> incumbent in the job (P_j) and the average wage for the job (W_j). Estimation of this relationship would require direct measures of the marginal revenue product of work groups that are comparable across jobs and across firms. Such data are not available. It is assumed that P_j-W_j summed over a worker's life cycle is uncorrelated with schooling and GIA (ie. that $\underline{B}_4=\underline{0}$).[8] The paper focuses its analysis on the second and third terms of the identity (7).

Analysis of GATB Validation Studies

Data on the relative productivity of a large and reasonably representative sample of workers is available from the US Employment Service's program for revalidating the General Aptitude Test Battery (GATB). This data set contains data on job performance, the 9 GATB "aptitudes" and background data on 36,614 individuals in 159 different detailed occupations defined by a unique 9-digit Dictionary of Occupational Titles code number. Professional, managerial and high level sales occupations were not studied but the sample is quite representative of the rest of the occupational distribution. It ranges from drafters and laboratory testers to hotel clerks and knitting-machine operators. A total of 3052 employers participated. Since a major purpose of these validation studies was to examine the effects of race and ethnicity on the validity of the aptitude test battery, the firms that were selected tended to have an integrated workforce in that occupation. Firms that used aptitude tests similar to the GATB for selecting new hires for the job being studied were excluded. The employment service officials who conducted these studies report that this last requirement did not result in the exclusion of many firms.

Each worker took the GATB test battery and supplied information on their age, education, plant experience and total experience. Plant experience was defined as months working in that occupation for the current employer. Total experience was defined as months working in the occupation for all employers. The dependent variable for this study is a sum of two separate administrations (generally two weeks apart) of the Standard Descriptive Rating Scale. This rating scale (available from the author), obtains supervisory ratings of 5 aspects of job performance (quantity, quality, accuracy, job knowledge and job versatility) as well as an "all around" performance rating. Some studies employed rating scales specifically designed for that occupation and in one case a work sample was one of the job performance measures. None of the studies used ticket earnings from a piece rate pay system as the criterion. Studies which used course grades or tests of job knowledge as a criterion were excluded. Firms with only one employee in the job classification were excluded, as were individuals whose reported work experience was inconsistent with their age.

Academic achievement is proxied by two GATB composites, G and N.[9] General Intellectual Achievement (G) is an average of normalized scores on a vocabulary test, an arithmetic reasoning test and a 3-dimensional spatial relations test. The mathematical achievement index (N) is an average of normalized scores on the same arithmetic reasoning test and on a numerical computations test. Both were put into a Population SD metric by dividing by 20.

Our objective is to explain variations in performance across workers doing the same job at the same firm. Because wage rates, average productivity levels and the standards used to rate employees vary from plant to plant, mean differences in ratings across establishments were assumed to have no meaning. Only deviations from the mean for the establishment were analyzed. The variance of the job performance distribution was also standardized across establishments by dividing (R^m_{ij}-R^m_j) by the standard deviation of performance calculated for that firm (or 3 if the sample SD is less than 3).[10] The model fitted to the data was the following:

$$(11) \quad \frac{R^m_{ij}-R^m_j}{SD(R^m_j)} = R_{ij}-R_j = \theta_o + \theta_1 GIA_{ij} + \theta_2 S_{ij} + \theta_3 X_{ij} + v_1$$

where GIA_{ij}, S_{ij} are the GIA and schooling of the individual and X_{ij} is a vector of individual characteristics which includes gender, Black, Hispanic, age, plant experience, total occupational experience and their squares. Descriptive statistics are available in appendix A.

Table 2 presents estimates of equation 11 that were estimated in the full data set. The GATB achievement tests are clearly strongly correlated with relative job performance. Adding controls for race, gender, schooling, age, plant experience, total occupational experience and their squares does not significantly reduce the magnitude of this relationship. In model 3 a one population standard deviation test score differential on both tests results in a relative job performance differential of 16.9 percent of a SD(R), a within firm standard deviation of the job performance rating. [Note that the GIA gap between adults with 9 and 14 years of schooling is approximately one population standard deviation.] In contrast, schooling has a significant negative direct effect on relative job performance when measures of actual achievement are controlled. If they do not result in higher test scores, four additional years of schooling appear to reduce relative job performance by 9.6 percent of an SD(R). The negative effect of schooling together with the large positive effects of measured academic achievement is strong confirmation of the empirical relevance of signaling and implicit contracts theory.

These results, however, do not support Ivar Berg's (1970) claim that educated workers are systematically overpaid. Workers with high amounts of schooling are not reported by their supervisors to be less productive than others in their job. When G and N are not included in the model, schooling no longer has a negative effect on relative job performance. When equation 11 is estimated in the full sample, the coefficient on schooling is .006 (t=1.97) if schooling is entered alone and .011 (t=3.60) if gender, race, Hispanic, age, plant experience and occupational experience are controlled but test scores are not. When equation 1 is estimated under an assumption of employer specific fixed effects, the coefficient on schooling is .009 (t=2.48) if schooling is entered alone and .029 (t=7.79) if gender, race, Hispanic, age, plant experience and occupational experience are controlled but test scores are not.

Willis and Rosen found that academic achievement measured while the individual was in the armed forces had a larger impact on the wages of those with some college education than those who did not go to college. This interaction was tested by interacting the deviation of G from its mean with a dummy for more than 12 years of schooling. The results presented in row 4 of Table 2 reveal that academic achievement's effect on productivity is larger for college educated workers than for those with 12 or fewer years of schooling. A one population standard deviation achievement differential on both G and N raises a college educated worker's productivity by .205 SD(R)'s and a noncollege educated worker's productivity by .152 SD(R)'s.

It is well documented that the earnings payoff to academic achievement tends to grow with age (Hauser and Daymont 1977; Taubman and Wales 1974). One explanation of this pattern is that academic achievers tend to take jobs that offer a greater amount of on-the-job training and/or receive higher rates of return on their on-the-job training. A second explanation of the pattern is that employers may be better informed of the productivity of older workers. Promotions and turnover would have had more time to sort the older individual into a job in which wage truly equaled marginal product. An extreme version of this second scenario predicts that academic achievers should after a time have been promoted into a job in which they are no longer perform better than the average for that job.

This hypothesis was tested in our data by specifying interactions between age and G, between total occupational experience and G, between plant experience (tenure) and G and between plant experience and years of schooling. It was hypothesized that coefficients on the G interactions would be negative. When all four interactions were entered simultaneously, all were statistically insignificant. The tenure-G interaction had the largest negative coefficient so the model was reestimated with only the tenure-G interaction. The tenure-G interaction was equal to G deviated from its mean multiplied by a dummy for tenure greater than 59 months (the approximate mean for the sample). Results are reported in row 5 of Table 5. The coefficient on the tenure-G interaction is negative and significant at the 5 percent level.