A Note on School Quality, Educational Atainment and the Wage Gap

Srikanth Ramamurthy[*]

Norman Sedgley[†]

(Loyola University Maryland)

June 2017

Abstract

This paper explores the linkage between school quality, educational attainment and the wage gap. In a model of statistical discrimination based on both the quality and quantity of schooling, we show that lower quality education can, on average, lead to lower human capital accumulation and amplify the wage gap between different groups of individuals. Because blacks have lower access to good quality schools compared to whites, this link provides a novel explanation for the differences in black-white educational attainment and the resulting wage gap. This insight is also particularly relevant for the ongoing debate on public vs charter school programs. (JEL classification: J24, J71)

[*]*Address for correspondence*: Sellinger School of Business, Loyola University Maryland, 4501 N. Charles St., Baltimore, MD 21210, USA, *E-mail*: sramamurthy@loyola.edu, *Phone:* +1 (410) 617-5863

[†]*Address for correspondence*: Sellinger School of Business, Loyola University Maryland, 4501 N. Charles St., Baltimore, MD 21210, USA, *E-mail*: nsedgley@loyola.edu, *Phone:* +1 (410) 617-2848

1 Introduction

Since the end of the Civil War, significant progress had been made in closing the wage gap between blacks and whites. By 1940, the relative wage, measured by the black-white weekly earnings ratio for men aged 25-34, had risen to about 50% and by 1980 it had risen to 80%. (O'Niell 1990; Couch and Daly 2002). Progress in closing the wage gap ceased by 1980 and some studies suggest it actually widened slightly over the following decade. Couch and Daly (2002) report that their measurements suggest a wage gap of 30% by 1990 but falling again to 20% by 2000. There is a vast empirical literature studying the post-Civil War causes-of-and-impediments-to black economic progress that strives to explain this change in the trend towards wage convergence. The most popular explanations include continued differences in both the quantity and quality of education attained by blacks relative to whites, and a secular increase in the relative demand for skilled workers vis-a-vis their unskilled counterparts. Nonetheless, this literature reports a persistent wage gap of around 20% that remains unexplained.

Empirical evidence suggests that resources devoted to improving school quality, years of education, convergence in black-white skills (often measured by scores on standardized tests), as well as family background variables such as parental education and income are important determinants of wages (Card and Krueger 1992a, 1992b; Maxwell 1994; Neal and Johnson 1996; Carneiro, Heckman and Masterov, 2005). Today, even with similar input measures of school quality between schools with and without large minority populations, black students continue to have lower graduation rates from high school and are less likely to attend college. This is true even when the measured return to schooling is comparable for blacks and whites (Barrow and Rouse 2005). In 2000, among adults 25 years and older, 88% of whites attained a high school diploma compared to 79% of blacks. Similarly, 28% of whites had received a Bachelor's degree compared to 17% of blacks (U.S. Census Bureau 2002). At the same time, black students appear more selective about schooling choice than do whites. In other words, blacks who attend college are high achievers relative to other black students. Cameron and Heckman (2001) show that, controlling for ability, blacks are more likely to go to college than are whites.

In light of these observed differences in educational attainment between blacks and whites,

this paper explores theoretically a potential link between the quality of education received and educational attainment. From an individual's standpoint, the quality of school attended is likely determined by his residential district. Thus, school quality is beyond the control of the subject. In the parlance adopted in the literature, it is a *predetermined* or *exogenous* pre-market factor. In contrast, the decision to exit school and enter the workforce is, at least in part, made by the individual.[1] In reality, this decision is effected by several factors, key among which is the expected future labor market outcome. Consequently, if potential employers also statistically discriminate based on the quality of education, it can adversely affect an individual's pre-market decision of educational choice.

In Section 2 below we develop a model to capture this idea. Our model integrates dynamic human capital choice with the framework of statistical discrimination in Aigner and Cain (1977). A key assumption of the model is that lower quality school provides a noisier signal of the individual's potential productivity. An important result that emanates from this model is that lower quality schooling leads to lower educational attainment. This, in turn, amplifies the wage gap between groups of individuals that attend schools of varying quality. We provide some concluding remarks in Section 3 relating to the ongoing debate on public and charter school programs in the US.

2   Model of Endogenous Schooling Choice

The model involves two agents - individuals and firms. As discussed in the introduction, individuals do not have a choice between various qualities of schools. We suppose that it is predetermined largely by an individual's residential district. Once an individual is placed in a school of a particular quality, he makes an optimal decision on years of schooling, conditional on the firm's wage offer function. This wage offer function, in turn, depends on an individual's years of schooling and the quality of school attended, both used in conjunction as a proxy for the individual's unobserved productivity. We formulate the equilibrium wage-education choice conceptually as a two-stage process[2]: firms decide on the optimal wage

---

[1] Much of the literature on wage gap has also treated the quantity of education as an exogenous pre-market factor, at least in part because in the empirical context it is difficult to endogenize years of schooling.

[2] The decision stages need not necessarily be sequential in nature and could well be modeled as simultaneous move.

to offer conditional on the quantity (and implicitly on the quality) of schooling, whereas individuals decide on the optimal quantity of schooling conditional on the wage and quality of school they attend.

2.1 Wage Offer Function

Our wage-offer function is based on the framework of Aigner and Cain's (1977) - henceforth referred to as AC77 - version of Phelp's (1972) model. We focus on a simple extension that incorporates statistical discrimination based on school quality, ϕ, in addition to years of schooling, s. The motivation for this extension comes directly from the observation that the black population in much of the United States has significantly lower access to good quality schools compared to the white population. Specifically, we model this here in terms of school quality attended by the average black male vs the average white male, denoted, respectively, by ϕ_B and ϕ_W, with $\phi_B < \phi_W$.[3] Subsequently, we show in the following subsection that such quality-based discrimination can, as observed in reality, lead to lower schooling choice on average for individuals attending lower quality schools.

Consider the *Basic Model* in AC77. With actual productivity of an individual not directly observed, at least at the time a job offer is tendered, employers rely on some measurable signal for hiring and wage offer decisions. Consistent with our story, we model this signal as the individual's years of schooling, though one could equally well think of alternative measures considered in the literature such as a composite achievement score. Suppose that, because of network effects, access to educational resources etc., lower quality schooling sends a noisier signal of true productivity:

$$s = y + u;\,^{4} \qquad u \sim \mathcal{N}(0, \sigma_u^2(\phi)), \ \sigma_u'(\phi) < 0$$

With $\phi_B < \phi_W$ then, for any given level of education, the signal of productivity sent by a black individual is more noisy than that sent by a white individual. It is worth stressing here that the differences in signal noise arise solely because of the differences in quality of

---

[3]More generally, one could model this in terms of the distribution, $F(\phi)$, of school quality attended by the two groups.

[4]To eliminate concerns of units of measurement, suppose that all measurements are in terms of cost equivalence to some numeraire good, say, money.

education and are independent of racial or other factors.

As in AC77, further suppose that $y \sim \mathcal{N}(\bar{y}, \sigma_y^2)$. Thus, there is no apriori difference in the innate productivity between individuals.[5] Instead, the only factor that differentiates individuals is the exogenously allocated school quality. Assuming that the signal noise is independent of innate productivity, the wage-offer by a profit-maximizing firm, conditional on an individual's observed years of schooling and school quality is:

$$w(s; \phi) = E(y|s; \phi) = (1 - \gamma(\phi))\,\bar{y} + \gamma(\phi)s \qquad (2.1)$$

where $\gamma(\phi) = \dfrac{\sigma_y^2}{\sigma_y^2 + \sigma_u^2(\phi)} > 0$ with $\gamma'(\phi) > 0$. This wage offer equation is identical to equation (2) in AC77 except that it is also now implicitly a function of ϕ.

The following points about this wage-offer function are noteworthy:

1. The 'implicit' qualifier above needs further clarification. While firms take into account both the quantity and quality of schooling when deciding on the wage offer, they cannot, of course, explicitly discriminate based on school quality. That is, if two groups of individuals had the same years of schooling but attended schools of different quality, the group with the lower quality schooling cannot receive a systematically lower wage. This is reflected in the wage offer equation by the fact that taking a conditional expectation with respect to s completely rids the equation of ϕ:

$$E_s w(s; \phi) = E_s[E(y|s; \phi)] = \bar{y}$$

   Thus, the average or expected wage for any given years of schooling is the same for all individuals. For this reason, and also because s is the individual's choice variable while ϕ is not, we separate the two arguments by a semicolon.

2. Following the previous point, while w is strictly increasing in s: $\partial w/\partial s = \gamma > 0$, the impact of an increase in ϕ is ambiguous on w: $\partial w/\partial \phi \gtreqless 0$ as $s \gtreqless \bar{y}$.

3. This wage offer equation is a function of years of schooling and not the equilibrium

---

[5] This point relates to AC77's critique of Phelps (1972) that assumes differences in both the mean and variance of innate ability between Blacks and Whites.

wage outcome that is determined after the individual attending a particular school quality has decided on years of schooling. This is derived in the following subsection.

2.2 Human Capital Choice and Equilibrium Wages

Next consider the optimal human capital choice of an individual who attends a school of given quality ϕ. Individuals make the decision regarding when to end their formal education and join the workforce. This decision is made by incorporating their knowledge of the expected wage offer (based on the quality and quantity of education) and the costs of continuing their education. To keep matters simple, the cost of continuing education is assumed to be equal to the opportunity cost of not entering the labor force given current schooling s. Then the decision to continue schooling for an additional s_i years is based on maximizing the discounted present value of lifetime wages, given the opportunity cost of foregoing employment with current schooling. Denoting the discount rate θ, the individual's optimization problem is

$$\max_{s_i} \int_{s+s_i}^{\infty} [(1 - \gamma(\phi))\bar{y} + \gamma(\phi)s_i]e^{-\theta(z-s)}dz \tag{2.2}$$

The first order condition to this optimization problem yields

$$\gamma(\phi) \int_{s+s_i}^{\infty} e^{-\theta(z-s)}dz - [(1 - \gamma(\phi))\bar{y} + \gamma(\phi)s_i]e^{-\theta s_i} = 0$$

the interior solution to which we write as

$$\frac{\gamma(\phi)}{\theta} - [(1 - \gamma(\phi))\bar{y} + \gamma(\phi)s_i] = 0 \tag{2.3}$$

This is the standard condition that, at the margin, the benefit of continuing schooling equal its cost[6]. Finally, it is straightforward to verify that the second order condition is satisfied because the slope of MB equals zero, which is less than the slope $\gamma(\phi)$ of MC.

---

[6]The MB is the discounted PV of increase in lifetime wages from an additional year of schooling, whereas the marginal cost is a one period opportunity cost in the form of forgone wages.

Solving explicitly for the individual's optimal schooling choice, we obtain

$$s_i^* = \frac{1}{\theta} - \frac{1 - \gamma(\phi)}{\gamma(\phi)} \bar{y} \tag{2.4}$$

In this expression, the optimal schooling choice depends on school quality. Further, as observed in practice, the decision of years of schooling increases with school quality and vice-versa. This is readily seen in the following expression:

$$\frac{d\, s_i^*}{d\, \phi} = \frac{\gamma'}{\gamma^2} \bar{y} > 0$$

The resulting impact on wage distribution is obtained by substituting back the solution for optimal schooling in the wage equation (2.1).

$$w^*(s_i^*, \phi) = \frac{\gamma(\phi)}{\theta} \tag{2.5}$$

Clearly, the equilibrium wage is an increasing function of school quality. The resulting implication for wage distribution is that if blacks on average attended schools of lower quality, which is the case in reality, their equilibrium wages, on average, will also be lower compared to whites. This result is straightforward under complete racial segregation into low and high quality schools, as presented above.

Under incomplete segregation, one would need to make further assumptions regarding the functional form of $\sigma_s(\phi)$ to derive an analytical expression for wage distribution. Under the simplistic assumption of two types of schools – low and high quality – with associated signal noise σ_l and σ_h, $\sigma_l > \sigma_h$, suppose that α proportion of blacks attends the lower quality school. Then

$$\gamma = \sigma_y^2 / (\sigma_y^2 + \alpha \sigma_l^2 + (1 - \alpha) \sigma_h^2),$$

leading to the result that

$$\frac{d\, \gamma}{d\, \alpha} = -\frac{\sigma_y^2 (\sigma_l^2 - \sigma_h^2)}{(\sigma_y^2 + \alpha \sigma_l^2 + (1 - \alpha) \sigma_h^2)^2} < 0$$

which, in turn, implies that equilibrium wages rise as the proportion of blacks attending

lower quality schools declines.

3 Conclusion

This paper explores a potential key link between the quality of school attended and years of education to reexamine the wage gap between black and white males. We argue that while the former might be predetermined by several factors, the latter is a choice variable of the individual, which among other factors, is affected by the quality of school attended itself. In a model of statistical discrimination based on the quality of schools attended by black men verses white men, we show that forward looking individuals, in their goal to maximize their expected labor market outcome in the future, weigh both their marginal benefits and costs of education. A key implication of the model is that lower school quality decreases educational attainment, and, consequently, wages for blacks, given the generally lower quality of schools attended by them.

We conclude by noting the importance of basing future empirical work on more rigorous structural models that highlight the role of human capital choice in determining wages and the role of expected labor market outcomes in determining the components of human capital subject to individual choice. This paper has a clear policy implication as the US moves to a debate on Charter schools, lottery systems and voucher programs: if the lottery school system gives individuals located in lower income neighborhoods (and, hence, attending lower quality schools) a chance to attend better schools, then the wage outcomes for the population of low educational attainment youth can be impacted. We realize that this would not completely mitigate the higher incidence of school dropout rates encountered in lower quality schools. More homogeneity, however, would likely have better schooling outcomes in terms of educational attainment for those living in less privileged neighborhoods. The model's implications deserve further investigation and careful consideration from a policy perspective.

4   References

Aigner, D., and G. Cain (1977) "Statistical Theories of Discrimination in the Labor Market", *Industrial and Labor Relations Review*, 30, 175-87

Barrow, L., and C. Rousse (2005) "Do Returns to Schooling Differ by Race and Ethnicity?", *The American Economic Review, Papers and Proceedings of the One Hundred and Seventeenth Annual Meeting*, 95, 2, 83-7.

Cameron, S., and J. Heckman (2001) "The Dynamics of Educational Attainment for Black, Hispanic, and White Males", *Journal of Political Economy*, 109, 455-99.

Card, D., and A. Krueger (1992a) "Does School quality Matter? Returns to Education and the Characteristics of Public Schools in the United States", *The Journal of Political Economy*, 100, 1, 1-40.

Card, D., and A. Krueger (1992b) "School Quality and black-white Relative Earnings: A Direct Assessment", *The Quarterly Journal of Economics*, 107, 1, 151-200.

Carneiro, P, J. Heckman, and D. Masterov (2005) "Labor Market Discrimination and Racial Differences in Premarket Factors", *Journal of Law and Economics*, XLVIII, 1-39.

Castello-Climent, A., and R. Domenech (2008) "Human Capital Inequality, Life Expectancy, and Economic Growth", *The Economic Journal*, 118, 653-77.

Couch, K., and M. Daly (2002) "Black-White Wage Inequality in the 1990s: A Decade of Progress", *Economic Inquiry*, 40, 1, 31-41.

Maxwell, N. (1994) "The Effect on Black-White Wage Differences of Differences in the Quantity and Quality of Education", *Industrial and Labor Relations Review*, 47, 2, 249-64.

Neal, D., and W. Johnson (1996) "The Role of Pre Market Factors in Black-White Wage Differences", *The Journal of Political Economy*, 104, 5, 869-95.

O'Neill, J. (1990) "The Role of Human Capital in Earnings Differences Between Black and White Men", *The Journal of Economic Perspectives*, 4, 4, 25-45.

Phelps, E. S. (1972) "The Statistical Theory of Racism and Sexism", *American Economic Review*, 62 (4) 659-661.

U.S. Census Bureau (2002) "The Big Payoff: Educational Attainment and Synthetic Estimates of Work-Life Earnings", Current Population Reports, p23-210.