Job Market Signaling and Returns to Education[*]

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Abstract

We compare two partially separating equilibria in a job market signaling model with unproductive education. We find that in one of the two equilibria, the fraction of the population with a threshold education level is higher even though the cost of education is higher. Moreover, compared to the other equilibrium, the population faces a higher threshold education level, yet the educated attain lower wages. The reason for this result is that the gross return to education can be higher despite the higher cost of education and a higher threshold.

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1 Introduction

The US has experienced two dramatic changes in the education sector since the 1980s. The first was an extraordinary expansion of higher education (Goldin and Katz, 2008).[1] The second was a sharp increase in the college wage premium, despite the large increase in supply (Katz and Murphy, 1992; Acemoglu, 2002).[2] Two theories are used to explain the source of the college wage premium. The human capital model (Schultz, 1961; Becker, 1964; Mincer, 1974) postulates that college education helps an individual accumulate human capital and increases wages by directly increasing the worker's productivity. The signaling model (Spence, 1973) postulates that college education helps a worker signal to firms that he has higher innate ability than a high school graduate, but education itself is unproductive. Most studies that aim to explain the rising college wage premium since the 1980s assume that firms can perfectly observe individual workers' skills (although researchers may not). This assumption rules out the ability signaling potential of college education.

In this paper, we propose a job market signaling model capable of displaying multiple partially separating equilibria. Under the same model parameterizations, we compare two equilibria where in one equilibrium more

[1] According to data from the National Center for Education Statistics, in 1980, 25.7% of 18- to 24-year-olds enrolled in degree-granting colleges, and the number increased to 41.0% in 2012 (Digest of Education Statistics, Table 302.60).

[2] The increase in returns to education is one of the major motivating factors of the empirical literature on wage structure and wage inequality (e.g., Katz and Murphy, 1992; Bound and Johnson, 1992; Juhn, Murphy and Pierce, 1993). Autor and Katz (1999) provide a comprehensive review of this literature.

people acquire threshold college education and the returns to college are also higher. We show that in such an environment where multiple equilibria coexist, an expansion of college education and a rising college wage premium can be experienced if the economy moves from an equilibrium with low education threshold to one with high threshold.

The model builds on the seminal work by Spence (1973). Firms have incomplete information on workers' productivity, and costs of signaling are negatively correlated with productivity. In the original Spence model, workers belong to two productively distinct groups in the population. In a separating equilibrium, all high-ability workers would acquire threshold education and all low-ability workers would not. Although the equilibrium value for the threshold education is not unique, its change has no effect on the college attendance rate or the college wage premium.

In our model, we consider a continuum of workers with different productivities. This distinction is important because the number of people that acquire threshold education in our model depends on a threshold ability or productivity level. Individuals with above-threshold level of ability would choose to acquire threshold education, signaling themselves as high ability, whereas those with below-threshold level of ability would not acquire any education. With a continuum of abilities or productivities, such an equilibrium is partially separating, since workers with above-threshold level of ability acquire some education and workers with below-threshold level of ability acquire none. The equilibrium is not perfectly separating because there are workers with different abilities who end up with the same level of education. When we compare two select partially separating equilibria in this model, we find that in the second "high threshold" equilibrium, the fraction of the population that acquires threshold education is higher even though the cost of education is higher, the threshold education level is higher, and wages of the educated are lower than in the first, the "low threshold" equilibrium.[3] The reason is that gross returns to education can be higher despite a higher cost of education and a higher threshold.

At the core of our analysis lie two elementary statistical insights. Suppose that the population is divided into three groups, a bottom group with low average ability X, a middle group with intermediate average ability Y, and a top group with high average ability Z so that $X < Y < Z$. In the "low threshold" equilibrium, both the bottom group and the middle group choose zero education. The combined group has an average ability $W_L^* \in (X, Y)$. The top group chooses the low threshold level of education and has average ability $W_H^* = Z$. In the "high threshold" equilibrium, the bottom group chooses zero education and has average ability $W_L^{**} = X$. The middle group and the top group choose the high threshold level of education. The combined group has average ability $W_H^{**} \in (Y, Z)$. We obtain that $W_L^{**} = X < W_L^* < Y < W_H^{**} < Z = W_H^*$, that is, in the second equilibrium, the average ability of the uneducated is lower than in the first equilibrium and the average ability of the educated is lower as well. This is the first crucial insight. Next let us assume that the average ability of the middle group is very

[3]Comparison of the two equilibria further shows that all individuals fare worse in the high threshold equilibrium.

close to the average ability of the top group while the average ability of the bottom group is much lower. Then the drop from W_H^* to W_H^{**} tends to be rather small while the drop from W_L^* to W_L^{**} is much larger. More generally, $W_H^{**} - W_L^{**} > W_H^* - W_L^*$ if *ceteris paribus* Y is sufficiently large (cf. Lemma 1). This constitutes the second crucial insight. In our model, the differences $W_H^{**} - W_L^{**}$ and $W_H^* - W_L^*$ represent the gross returns to college education. A greater gross return to college education suggests that a higher education threshold is sustainable in equilibrium.

2 Related Literature

No consensus has been reached in the literature on the relative importance of human capital versus ability signaling in explaining schooling choices and returns to education. Taubman and Wales (1973), Riley (1979), Lang and Kropp (1986), and Bedard (2001) show empirical evidence consistent with a signaling model and inconsistent with a pure human capital model, whereas Layard and Psacharopoulos (1974), Wolpin (1977), and Albrecht (1981) find little support for the signaling hypothesis.[4] More recently, Fang (2006) estimates a structural model of education choices and wage determination to disentangle the relative contribution of human capital and ability signaling to the college wage premium. He finds that ability signaling accounts for approximately one-third of the college wage premium. Our model shows that ability signaling may play a significant role in determining both the *level* of college wage premium and the *change* of college wage premium over time.

[4] See Weiss (1995) for a survey on human capital versus signaling explanations of wages.

This paper is also closely related to a growing literature seeking to explain the rising college wage premium in the US. The average wage of workers with a particular education level can be considered a function of the price of skills specific to an education group and the quantity of skills the average worker possesses. For simplicity, assume that skills consist of both (unobserved) innate ability and skills accumulated via education. Much of the previous literature has focused on reasons why skill prices may have changed, typically without distinguishing returns to unobserved ability and to education: for example, changes due to skill-biased technological change (Katz and Murphy, 1992; Bound and Johnson, 1992; among others), capital-skill complementarity (Krusell et al., 2000), or international trade (Murphy and Welch, 1991; Feenstra and Hanson, 1996).[5] A recent paper by Hendricks and Schoellman (2014) considers the possibility that changes in the college wage premium may be driven by composition effects (changes in the composition of ability between high school and college) in a human capital model. Our model proposes a complementary channel: the rising college wage premium is driven by increasing ability sorting because of labor market signaling.

Job market signalling can be modeled as a signalling or sorting game (where the informed parties move first) or as a screening game (where the uninformed parties move first). For a brief exposition see Chapter 10 in Wolfstetter (1999). For a detailed survey, see Riley (2001). The equilibrium

[5] Taber (2001) is an exception. He investigates whether the growing college wage premium is due to an increase in returns to unobserved ability or an increase in returns to college.

outcomes considered in this paper can be obtained via partially separating sequential equilibria in a signaling game with a continuum of types. Mailath (1987) deals with the existence of perfectly separating equilibria in signaling games with a continuum of types.

3 The Model

Consider a continuum of individuals $\alpha \in [0,1]$. Individual α has the ability or productivity $f(\alpha)$, where $f : [0,1] \to [0,1]$ is a continuous and non-decreasing function with $f(0) = 0$ and $f(1) = 1$. Each individual α chooses a level of education $e \geq 0$. When α chooses (the level of) education e, she incurs a cost $C(\alpha, e)$ where the differentiable cost function $C(\alpha, e)$ satisfies $C(\alpha, 0) = 0$, $\partial C/\partial e > 0$ and $\partial C/\partial \alpha < 0$ in case $e > 0$. Suppose that a wage schedule $W(e)$ exists. Then $e(\alpha)$ denotes α's (largest) optimal choice of education,

$$e(\alpha) = \max\{\arg\max_{e} [W(e) - C(\alpha, e)]\}.$$

A **partially separating equilibrium** with two wage levels $W_L^* < W_H^*$ is given by thresholds $e^* > 0$ and $\alpha^* \in (0,1)$ such that:

(i) $$W(e) = \begin{cases} W_L^* & \text{if} \quad e < e^*; \\ W_H^* & \text{if} \quad e \geq e^*. \end{cases}$$

(ii) $$e(\alpha) = \begin{cases} 0 & \text{for} \quad \alpha < \alpha^*; \\ e^* & \text{for} \quad \alpha \geq \alpha^*. \end{cases}$$

(iii) W_L^* is the average ability of individuals in $[0, \alpha^*)$.
W_H^* is the average ability of individuals in $[\alpha^*, 1]$.

Specifically, if the education threshold e^* stands for obtaining a college degree, then in such a signaling equilibrium, $\Delta^* = W_H^* - W_L^*$ is the gross return to college education. $\Delta^* - C(\alpha, e^*)$ is the net return to college education for individual α, which is zero for the marginal individual α^*, negative for $\alpha < \alpha^*$, and positive for $\alpha > \alpha^*$.

We are going to show the following:

Proposition 1. *For some cost functions C and productivity functions f, there exist two partially separating equilibria, a low threshold equilibrium E^* and a high threshold equilibrium E^{**} such that in E^{**},*

(a) *the education threshold is higher;*

(b) *both wages are lower;*

(c) *the gross return to education is higher; and*

(d) *a larger fraction of the population obtains an education.*

Moreover, equilibrium E^{**} may occur after ceteris paribus *the cost of education has become significantly higher.*

The two key ideas presented in the introduction provide the intuition behind the result. In a nutshell, Proposition 1 combined with Proposition 2 below says that when we move from the low threshold to the high threshold equilibrium, while all economic fundamentals remain unchanged, the college premium goes up, more people go to college, they spend more time and money in college (going for double majors or advanced degrees and facing higher tuition), absolute wages go down (with or without a college degree) and everybody is worse off. In particular, more people attending college causes higher college premium instead of mitigating it.

4 Analysis

4.1 Lead Example

Let $C(\alpha, e) = \dfrac{1-\alpha}{1+(1-\alpha)} \cdot e = \dfrac{1-\alpha}{2-\alpha} \cdot e$ and $f(\alpha)$ be as in Figure 1.

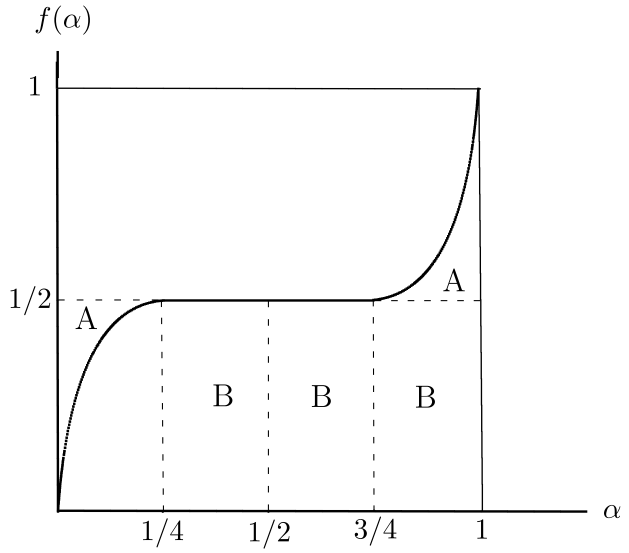

Figure 1: Ability

We consider two partially separating equilibria:

EQUILIBRIUM E* (low threshold equilibrium). $\alpha^* = 1/2$, $W_L^* = 2(2B - A)$, $W_H^* = 2(2B + A), \Delta^* = 4A, e^* = 12A$. Starting from $\alpha^* = 1/2$, one can compute W_L^*, W_H^* and Δ^*. e^* is obtained from the equation $C(\alpha^*, e^*) = \Delta^*$.

EQUILIBRIUM E** (high threshold equilibrium). $\alpha^{**} = 1/4$, $W_L^{**} = 4(B-A)$, $W_H^{**} = \frac{4}{3}(3B+A), \Delta^{**} = \frac{16}{3}A, e^{**} = \frac{112}{9}A$. Starting from $\alpha^{**} = 1/4$, one can compute W_L^{**}, W_H^{**} and Δ^{**}. e^{**} is obtained from the equation $C(\alpha^{**}, e^{**}) = \Delta^{**}$.

The average abilities W_L^{**} and W_H^{**} in equilibrium E** are lower than the average abilities W_L^{*} and W_H^{*}, respectively, in equilibrium E*. This effect is to be expected and stems from the previously uneducated who join the ranks of the college educated being on average more able than the average member of the group they leave behind and less able than the average member of the group they join. The effect holds in particular for any increasing f. Two further effects are less obvious and less general:

1. $\alpha^{*} > \alpha^{**}$ while $e^{**} > e^{*}$. That is, more individuals become educated although it becomes more demanding to reach the threshold. *Ceteris paribus*, this effect depends on the cost function. For an alternative choice of cost function of separable form $C(\alpha, e) = c(\alpha) \cdot e$, the reverse inequality $e^{**} < e^{*}$ may prevail. For instance, with $C(\alpha, e) = (1-\alpha) \cdot e$, we obtain $e^{**} = \frac{64}{9}A$ and $e^{*} = 8A$. Then the increase of the number of people earning a college degree can be explained in part by the lower threshold. The opposite possibility pursued here, a greater number of college graduates despite a higher education threshold, is more intriguing.

2. $\Delta^{**} > \Delta^{*}$ while $W_H^{**} < W_H^{*}$. That is, the gross return to college education increases even though wages for college graduates have declined. The

reason is that the drop from W_L^* to W_L^{**} is even larger. This phenomenon hinges upon the distribution of abilities. For instance, with $f(\alpha) = \alpha^2$ and values $\alpha^* = 1/2$ and $\alpha^{**} = 1/4$ as before, $\Delta^{**} < \Delta^*$ results. A skill distribution as in our example demonstrates that college education can remain as attractive or become more attractive even when real wages for the college educated decline or the cost of education increases.

4.2 Ramifications

Whereas $\Delta^{**} > \Delta^*$ does not hold for every continuous and non-decreasing function f, it holds for a broad class of such functions. For given $\alpha^* = 1/2$ and $\alpha^{**} = 1/4$, let

X be the average ability for $\alpha \in [0, \alpha^{**})$;

Y be the average ability for $\alpha \in [\alpha^{**}, \alpha^*)$;

Z be the average ability for $\alpha \in [\alpha^*, 1]$.

Then $W_H^* = Z$, $W_L^* = \frac{1}{2}(X+Y)$, $W_H^{**} = \frac{1}{3}Y + \frac{2}{3}Z$, $W_L^{**} = X$, and
$\Delta^* = Z - \frac{1}{2}(X+Y)$, $\Delta^{**} = \frac{1}{3}Y + \frac{2}{3}Z - X$. Consequently, we obtain

Lemma 1. $\Delta^{**} > \Delta^* \iff 5Y > 3X + 2Z$.

The lemma means the gross return to college education increases if Y, the average ability of those joining the college educated is sufficiently high. Consider the following situation.

Second Example. Take the extreme case of a discontinuous f with $X = 0$, $Y = Z = 1$. Then $\Delta^* = 1/2$, $\Delta^{**} = 1$ and $e^* = 3/2$, $e^{**} = 7/3$ with the cost function $C(\alpha, e) = \frac{1-\alpha}{2-\alpha}e$. More interestingly, the qualitative comparative statics are preserved if equilibrium E^{**} occurs in an environment where the costs of education are 40% higher, i.e., are given by $1.4 \cdot C(\alpha, e)$. Then $e^* = 3/2$, $e^{**} = 5/3$. Hence, the particular specification demonstrates the possibility that a larger fraction of the population obtains a college education although the cost of education has increased significantly, the threshold has increased, and wages have declined, thereby showing Proposition 1.

Incidentally, the condition $5Y > 3X + 2Z$ is satisfied for all strictly increasing and strictly concave f, for example $f(\alpha) = \alpha^{1/2}$. However, this functional form is rather implausible.

A variation of the example illustrates how the college premium increases as more and more people attend college. Suppose f assumes values X, Y and Z in the intervals $[0, 1/4)$, $[1/4, 1/2)$ and $[1/2, 1]$, respectively, and individuals with $\alpha \geq 1/2 - \beta$ go to college where $0 \leq \beta \leq 1/4$. Then college attendance increases as β increases. It moves from 50% to 75% as β moves from 0 to 1/4. The college premium (gross return to education) is a function $\Delta(\beta)$. If $3Y > X + 2Z$, then $\partial\Delta/\partial\beta > 0$ for all β, that is, the college premium is strictly increasing. In that case, $\Delta^{**} = \Delta(1/4) > \Delta(0) = \Delta^*$ and $5Y = 2Y + 3Y > 2X + X + 2Z = 3X + 2Z$, as to be expected.

We can always slightly modify a function f such as the one in Figure 1 to make it strictly increasing without altering the qualitative conclusions. We can slightly modify the function f in the second example to render it differentiable and strictly increasing without affecting the qualitative conclusions.

We have worked with the specifications $f(0) = 0$, $f(1) = 1$, $\alpha^* = 1/2$, $\alpha^{**} = 1/4$ for the sake of convenience. The scope of the analysis is by no means restricted to those values. Other features, such as extremely high salaries at the very top or moderately productive education, could be incorporated as well.

4.3 Welfare

In the basic example of Spence (1973), infinitely many separating equilibria exist that differ in the education threshold. A higher threshold makes high productivity workers worse off while low productivity workers are unaffected. In our context, all individuals may be worse off in one of two partially separating equilibria.

Proposition 2. *For cost functions, productivity functions and two partially separating equilibria E^* and E^{**} as in Proposition 1, all individuals are worse off in E^{**} than in E^*.*

Proof. Similar to our lead example and the second example, consider a model given by suitable functions f and $C(\cdot, \cdot)$ that has two partially separating equilibria E^* and E^{**} with properties (a)–(d) in Proposition 1 and corresponding values $\alpha^{**} < \alpha^*$, $W_L^{**} < W_L^*$, $W_H^{**} < W_H^*$, and $e^{**} > e^*$. Let $U^*(\alpha)$ and $U^{**}(\alpha)$ denote the corresponding equilibrium utilities for $\alpha \in [0, 1]$. For $\alpha \in [0, \alpha^{**})$, $U^{**}(\alpha) = W_L^{**} < W_L^* = U^*(\alpha)$. For $\alpha \in [\alpha^{**}, \alpha^*)$, $U^{**}(\alpha) = W_H^{**} - C(\alpha, e^{**}) < W_H^{**} - C(\alpha^*, e^{**}) < W_H^* - C(\alpha^*, e^*) = W_L^* = U^*(\alpha)$. The equality $W_H^* - C(\alpha^*, e^*) = W_L^*$ follows from the fact that α^* is the marginal individual in E^*. For $\alpha \in [\alpha^*, 1]$, $U^{**}(\alpha) = W_H^{**} - C(\alpha, e^{**}) <$

$W_H^* - C(\alpha, e^*) = U^*(\alpha)$. This proves the assertion.

In case the high threshold equilibrium E** exists with higher costs of education, that is, with a cost function $\widehat{C} \geq C$, then the assertion holds as well. This follows from $U^{**}(\alpha) = W_H^{**} - \widehat{C}(\alpha, e^{**}) \leq W_H^{**} - C(\alpha, e^{**})$ for $\alpha \in [\alpha^{**}, \alpha^*)$ and $U^{**}(\alpha) = W_H^{**} - \widehat{C}(\alpha, e^{**}) \leq W_H^{**} - C(\alpha, e^{**})$ for $\alpha \in [\alpha^*, 1]$.

■

The proof of Proposition 2 relies on the existence of a marginal individual, which is guaranteed by a continuum of types and not in a model with finitely many types. In contrast, one can construct models with finitely many (at least three) types that exhibit equilibrium features (a)–(d) of Proposition 1. However, a model with a continuum of types $\alpha \in [0, 1]$ facilitates the analysis and fosters intuition.

Spence (1973) further considers two populations that differ in sex but otherwise have identical distributions of characteristics. We can do the same and obtain an equilibrium like E* for men and an equilibrium like E** for women.

5 Concluding Remarks

We have presented a job market signaling model where two equilibria can have the properties asserted in Propositions 1 and 2. However, why would the economy move to an equilibrium that is inferior in all respects? Such a phenomenon might be a result of technological changes that have occurred in the past 30 years. Recent literature has documented that computer-based technologies have substituted for workers in performing routine cognitive and manual tasks that can be accomplished by following explicit rules and complement workers in performing non-routine analytic and interactive tasks (Autor, Levy, and Murnane, 2003). If direct observation and precise evaluation of an individual's productivity are much more difficult in non-routine job tasks than in the routine job tasks, then education screening should be used more extensively in occupations and industries with higher concentration of non-routine tasks. As computer-based technological changes increase demand for non-routine job tasks, education screening may become more important. Consequently, individuals will have more incentive to choose college education to "signal" their ability to employers.

The literature emphasizes that technological changes increase demand for high-skilled college labor and push up the college wage premium. We offer the alternative explanation that the college wage premium rises because technological changes increase job sorting. These two explanations of rising college wage premia have very different policy implications. In the first explanation, education directly increases the productivity of workers, whereas in the second explanation, education is productive only to the extent that it facilitates a better match between workers and jobs (Stiglitz, 1975). Therefore, they have different implications for the efficiency of the recent expansion of higher education.

References

Acemoglu, Daron. 2002."Technical Change, Inequality, and the Labor Market." *Journal of Economic Literature* 40 (1): 7-72.

Albrecht, James W. 1981. "A Procedure for Testing the Signaling Hypothesis." *Journal of Public Economics* 15 (1): 123-132.

Autor, David, and Lawrence F. Katz. 1999. "Changes in the Wage Structure and Earnings Inequality." *Handbook of Labor Economics* Vol. 3A. Orley Ashenfelter and David Card, eds. North Holland.

Autor, David H., Frank Levy, and Richard J. Murnane. 2003. "The Skill Content of Recent Technological Change: An Empirical Exploration." *Quarterly Journal of Economics* 118 (4): 1279-1333.

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

Bedard, Kelly. 2001. "Human Capital versus Signaling Models: University Access and High School Dropouts." *Journal of Political Economy* 109 (4): 749-775.

Bound, John, and George E. Johnson. 1992. "Changes in the Structure of Wages During the 1980's: An Evaluation of Alternative Explanations." *American Economic Review* 82 (3): 371-392.

Fang, Hanming. 2006. "Disentangling the College Wage Premium: Estimating a Model with Endogenous Education Choices." *International*

Economic Review 47 (4): 1151-1185.

Feenstra, Robert C., and Gordon H. Hanson. 1996. "Globalization, Outsourcing, and Wage Ineqaulity." *American Economic Review* 86 (2): 240-245.

Goldin, Claudia, and Lawrence F. Katz. 2008. *The Race between Education and Technology.* Cambridge, MA: Harvard University Press.

Hendricks, Lutz, and Todd Schoellman. 2014. "Student Abilities during the Expansion of US Education." *Journal of Monetary Economics*, 63 (1): 19-36.

Juhn, Chinhui, Kevin M. Murphy, and Brooks Pierce. 1993. "Wage Inequality and the Rise in Returns to Skill." *Journal of Political Economy* 101 (3): 410-442.

Katz, Lawrence F., and Kevin M. Murphy. 1992. "Changes in Relative Wages, 1963-87: Supply and Demand Factors." *Quarterly Journal of Economics* 107 (1): 35-78.

Krusell, Per, Lee E. Ohanian, Jose-Victor Rios-Rull, and Giovanni L. Violante. 2000. "Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis." *Econometrica* 68 (5): 1029-1053.

Lang, Kevin, and David Kropp. 1986. "Human Capital Versus Sorting: The Effects of Compulsory Attendance Laws." *Quarterly Journal of Economics* 101 (3): 609-624.

Layard, Richard, and George Psacharopoulos. 1974. "The Screening Hypothesis and the Returns to Education." *Journal of Political Economy* 82 (5): 985-998.

Mailath, George J. 1987. "Incentive Compatibility in Signaling Games with a Continuum of Types." *Econometrica* 55 (6): 1349-1365.

Mincer, Jacob. 1974. *Schooling, Experience and Earnings.* New York: Columbia University Press.

Murphy, Kevin M., and Finis Welch. 1991. "The Role of International Trade in Wage Differentials," in *Workers and Their Wages: Changing Patterns in the United States.* Washington DC: The AEI Press.

Riley, John G. 1979."Testing the Educational Screening Hypothesis." *Journal of Political Economy* 87 (5): S227-S252.

Riley, John G. 2001. "Silver Signals: Twenty-Five Years of Screening and Signaling." *Journal of Economic Literature* 39 (2): 432-478.

Schultz, Theodore W. 1961. "Investment in Human Capital." *American Economic Review* 51 (1): 1-17.

Spence, Michael. 1973. "Job Market Signaling." *Quarterly Journal of Economics* 87 (3): 355-374.

Stiglitz, Joseph E. 1975. "The Theory of 'Screening,' Education, and the Distribution of Income." *American Economic Review* 65 (3): 283-300.

Taber, Christopher R. 2001. "The Rising College Premium in the Eighties: Return to College or Return to Unobserved Ability?" *Review of Economic Studies* 68 (3): 665-691.

Taubman, Paul J., and Terence J. Wales. 1973. "Higher Education, Mental Ability, and Screening." *Journal of Political Economy* 81 (1): 28-55.

Weiss, Andrew. 1995. "Human Capital vs. Signaling Explanations of Wages." *Journal of Economic Perspectives* 9 (4): 133-154.

Wolfstetter, Elmar. 1999. *Topics in Microeconomics: Industrial Organization, Auctions, and Incentives.* Cambridge, UK: Cambridge University Press.

Wolpin, Kenneth I. 1977. "Education and Screening." *American Economic Review* 67 (5): 949-958.