Signaling and the Education Premium*

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Abstract

A large portion of the rise in the education premium can be explained by a signaling theory of education which predicts that in the future, increases in the education level of the workforce will actually cause the education premium to rise, simply because different workers are being labeled as "highly educated". This prediction is supported by past behavior of the high school education premium. It runs counter to the view that increases in the relative supply of high education workers will always lower education's relative price. Suppose education does not affect an individual's productivity, but acts only as a signal of it because individuals select education based on their productivity, and wages are

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determined by productivity. It is shown that this implies additional education in the economy would not change the wage distribution. The education premium, or relative price of highly educated workers, is the ratio of mean high education wages to mean low education wages. If all workers gained more education, it would mean the "bar" (or productivity minimum) for a given level of education was being lowered. For example, suppose "highly educated" referred to a college education. If there were few college grads, lowering the bar (the most productive non-college grads becoming college grads) would reduce mean college wages significantly by adding lower productivity workers. Because there would be many non-college grads vs. college grads, a drop in the bar would cause a smaller fall in the mean non-college graduate wage by removing the most productive workers. It is shown that this implies the education premium would fall. However, if the bar was low enough so that there were many college grads and few non-college grads, the reverse would happen and further declines in the bar would cause education's relative price to rise. This effect would not be due to real changes, but to changes in labeling. To measure how large this effect could have been, simulations were done to create counterfactual education premiums for three definitions of "highly educated": (1) those with a college degree; (2) those with some college education; (3) those with a high school education. Premiums were created for the Census years 1950-2000 that hold the wage distribution the same as the previous decade, but allow the distribution of education across wage ranks to be the from the present year. These show what the premiums would have been if wages didn't change but education levels changed as in the

data. The simulations for (1) and (2) perform as expected: the simulated premiums fall when there are more high education individuals, and this can explain some or all of the observed changes in the education premium between the past six decades of census data. However, (3) also acts as the model predicts: because this definition has many more highly educated individuals, further increases in the supply of highly educated individuals lower the counterfactual premium. Thus, this model predicts that as the number of college graduates rises, additional grads will eventually cause the premium to increase.

1 Introduction

Much of the movement in the education premium over that last six decades can be explained by a signaling theory of education which predicts that in the future, increases in the education level of the workforce will actually cause the education premium to rise, simply because different workers are being labeled as "highly educated". This prediction is supported by the past behavior of the high school education premium. It runs counter to the view that an increase in the relative supply of high education workers will always lower education's relative price.

Consider if education was purely signaling, and had no effect on productivity, as an extreme case. This is a model similar to Stiglitz (1975) and Riley (1979). Suppose employers know the distribution of productivity in the economy, and offer each worker a wage that the employers believe equals the worker's productivity. Also, more productive workers are better at obtaining education, and employers know this. Therefore, more productive workers would obtain more education to differentiate themselves and get a higher wage offer. In equilibrium, the education rank of an individual would equal their productivity rank, and employers would offer a wage equal to productivity.

The returns to education are typically measured by the education premium, defined as the ratio of the average high education wage to the average low education wage, as in Katz & Murphy (1992).[1] Any meaningful measure of the gains to education would have to be equivalent such a ratio,[2] unless the difference in wages was used. However, due to inflation and labor productivity growth, the difference isn't as useful. High(low) education workers have more(less) education than a certain level, which will be called the "bar" for education. What is typically considered the "bar" has varied over time, but is usually considered to be a 4 year college education, as in Katz & Autor (1999).

Now suppose each individual increased their education level from the previous equilibrium. Every education rank would remain the same. Thus every worker would have the same wage as before. However, some workers who were previously too low in productivity/education to be over the bar are now counted as highly educated. This would lower both the average high education wage, since a worker was added who's wage is lower than the others, and the average

[1] Katz & Murphy (1992) use a more complex weighting method to compute high and low education wages.

[2] The case of many education catagories can be applied simply by having multiple wage ratios, or premia.

low education wage, since the highest . The effect on the education premium would depend on how many workers were currently highly educated. If there were very few high types, the addition of a few lower productivity workers would significantly lower the average high wage, while the average low wage would fall only slightly because there would be many of them. The premium would fall. Thus it would seem as if high and low skilled workers were different inputs, whose relative prices fall when relative supplies rise, as in Murphy & Welch (1992) and Katz & Murphy (1992).

But suppose education levels continued to rise and there were more and more highly educated workers, as is documented in the latter studies, among others. The effect on the premium would reverse, since the average high wage would only fall slightly from the addition of a few more marginal workers, while the average low wage would fall significantly. At this point, an increased relative supply of education causes its relative price to rise, unlike normal inputs in production. This entire effect is not due to any real wage changes, but only to how relative wages are defined.

Many studies, including the latter two, have noted the rising education premium, and concluded that demand for highly educated workers is rising. Under this hypothesis, additional education is advocated to compensate for the additional demand. However, if education does not affect productivity as explained above, and if the economy already has a certain number of high education workers, this will actually cause the premium to rise even more so.

Section 2 presents a signaling model similar to Stiglitz (1975), Riley (1979), and others, in which there is a continuum of worker types, and employers set wages according to the rule that a worker's wage rank in the economy is set equal to their education rank. The effects of additional education are described for the wage distribution of the 2000 census, using a simplification where all high education workers earn above all low education workers, as an illustration.

In section 3, census data from 1940-2000 is used to calculate the magnitude of the effects described above. To do this, the education premium is calculated for two counterfactual cases. In one case, the wage distribution from the previous period is held constant but the distribution of education conditional on wage rank is taken from the current period. The probability of education conditional on wage rank indicates which individuals are attaining education. This measures how the premium would have changed if the wage distribution had not, and so measures the "pure signaling" effect – the case where education has no effect on wages. The other case holds the conditional distribution of education constant, and allows the wage distribution to change, measuring the "pure wage" effect. Since it has been documented that the wage distribution has changed in variance by Juhn, Murphy, & Pierce (1993), Card & DiNardo (2002), and others, the "wage" effect is a measure of how much the premium would have changed for reasons other than education changes. Mean wages for each education level are also calculated for the "pure signaling" case in order to determine which changes in the education distribution are driving the results.

All of this is repeated for different definitions of "highly educated": (1) college graduates; (2) those with some college; (3) high school only graduates.

These three definitions differ in a key aspect, the percentage of the sample defined as "highly educated," with 1-3 going from least to greatest. This gives a much broader range for the data.

The results show that in every decade the pure signaling effect is significant, and sometimes larger than the wage effect. First consider the results for definition (1), college grads. In the 40s, the premium falls due both to the wage effect and because many low wage workers gained education, perhaps due to the GI bill. In the 50s and 60s, the premium rose due to both effects, where high wage workers attained education in larger numbers, perhaps as a return to the normal trend after the shock of the 40s. In the 70s, the premium falls entirely because of the signaling effect, where mostly marginal workers attained education in large numbers. The 80s were similar to the 50s and 60s, though the wage effect was more pronounced. The 90s had the premium rise due mostly to the wage effect. Over the entire period, 1940-2000, the signaling effect would have caused the premium to fall, while changes in the wage distribution dominated and caused the premium to rise. This is consistent with results in Katz & Murphy (1992) and Murphy & Welch (1992) that conclude that additional education supply would have caused the premium to fall, but other factors[3] overcame that effect. This is also consistent with the prediction that when there are few enough high educated workers, the signaling effect will cause the premium to fall, even though particular decades were dominated by the effects of wars and the later adjustments. Definition (2), for some college education,

[3] They call the other factors demand changes.

acts mostly like definition (1).

Definition (3) however, acts differently. In every decade except the 40s and 70s, and for the whole period, the signaling effect causes the premium to rise. In the 40s and 70s, the signaling premium falls because many low wage workers gained education, for the same reasons as above. Because the percentage of workers who are "highly educated" under this definition is so much higher, it is consistent with the prediction that eventually additional education will cause the premium to rise.

Section 4 concludes.

2 Model

2.1 Equilibrium

This model provides an example of how a signaling equilibrium could exist where each worker's wage rank is equal to their education rank, and changes in the population's education would not alter the wage distribution.

Suppose there is a continuum of workers indexed by productivity $\theta \sim G(\theta)$, where $G(\theta)$ is the c.d.f. of θ. Each worker can produce education, e, for themselves by allocating the fraction of time allocated to education, t, according to

$$e = f(\theta, t) \quad . \tag{1}$$

More productive workers can more easily attain a given education level, so that

$$f_\theta(\theta, t), f_t(\theta, t), f_{\theta t}(\theta, t) > 0 \quad . \tag{2}$$

Workers choose the amount of time allocated for education to maximize wages as a function of education level, $W(e)$, net of the time spent gaining education

$$\max_t (1-t) W(e) = \max_t (1-t) W[f(\theta, t)] \quad . \tag{3}$$

Employers know $G(\theta)$. Suppose employers offer wages by setting the worker's wage rank equal to their education rank. Let $D(e)$ denote the c.d.f. of education in the economy. Then employers would offer wages such that

$$W(e) = G^{-1}(D(e)) \quad , \tag{4}$$

or, alternatively,

$$D(e) = G(W(e)) \quad . \tag{5}$$

Conjecture 1 *There exists an equilibrium such that workers choose t to maximize wages net of time costs,*

$$t^* = \arg\max_t (1-t) W(e) = \arg\max_t (1-t) W[f(\theta, t)] \quad , \tag{6}$$

firms offer each worker a wage equal to productivity,

$$W[f(\theta, t^*)] = \theta \quad \textit{for all } \theta \quad ,$$

and each worker's education rank is equal to wage rank,

$$D(e) = G(W(e)) \quad \textit{for all } e \quad . \tag{7}$$

Proof Pending

2.2 The Effects of Uniform Education Gains on the Education Premium

In order to illustrate the effects of education supply on the premium when education does not affect the wage distribution, consider a simple example. Suppose everyone with education above e_0 was labeled as having high education, and everyone with education below e_0 was labeled as having low education. Let $w_0 \equiv W(e_0)$, so that everyone with wage-productivity greater than w_0 was labeled as highly educated. As everyone gains more education, w_0 will fall. The question is, what happens to the education premium as w_0 falls?

Let $w \sim N(w)$. Let $W^H(w_0)$ and $N^H(w_0)$ denote the mean wage and number of highly educated workers as a function of w_0, and $W^L(w_0)$ and $N^L(w_0)$ denote the mean wage and number of low educated workers. Then

$$\begin{aligned} N^H(w_0) &= \int_{w_0}^{\infty} dN(w) \quad , \qquad N^L(w_0) = \int_{-\infty}^{w_0} dN(w) \quad , \\ W^H(w_0) &= \tfrac{1}{N_H}\int_{w_0}^{\infty} w\,dN(w) \quad , \quad W^L(w_0) = \tfrac{1}{N_L}\int_{-\infty}^{w_0} w\,dN(w) \quad . \end{aligned} \tag{8}$$

Then the education premium as a function of w_0 is $\frac{W^H(w_0)}{W^L(w_0)}$. From the above,

$$\frac{\partial\left(\frac{W^H(w_0)}{W^L(w_0)}\right)}{\partial w_0} = \frac{n(w_0)}{W^L(w_0)}\left(\frac{W^H(w_0)}{W^L(w_0)}\frac{1}{N^L(w_0)}\overset{(-)}{\left(W^L(w_0)-w_0\right)} + \frac{1}{N^H(w_0)}\overset{(+)}{\left(W^H(w_0)-w_0\right)}\right) \tag{9}$$

$$= \frac{n(w_0)}{N^H N^L \left(W^L(w_0)\right)^2}\left(TW^H(w_0)\overset{(-)}{\left(W^L(w_0)-w_0\right)} + TW^L(w_0)\overset{(+)}{\left(W^H(w_0)-w_0\right)}\right) \tag{10}$$

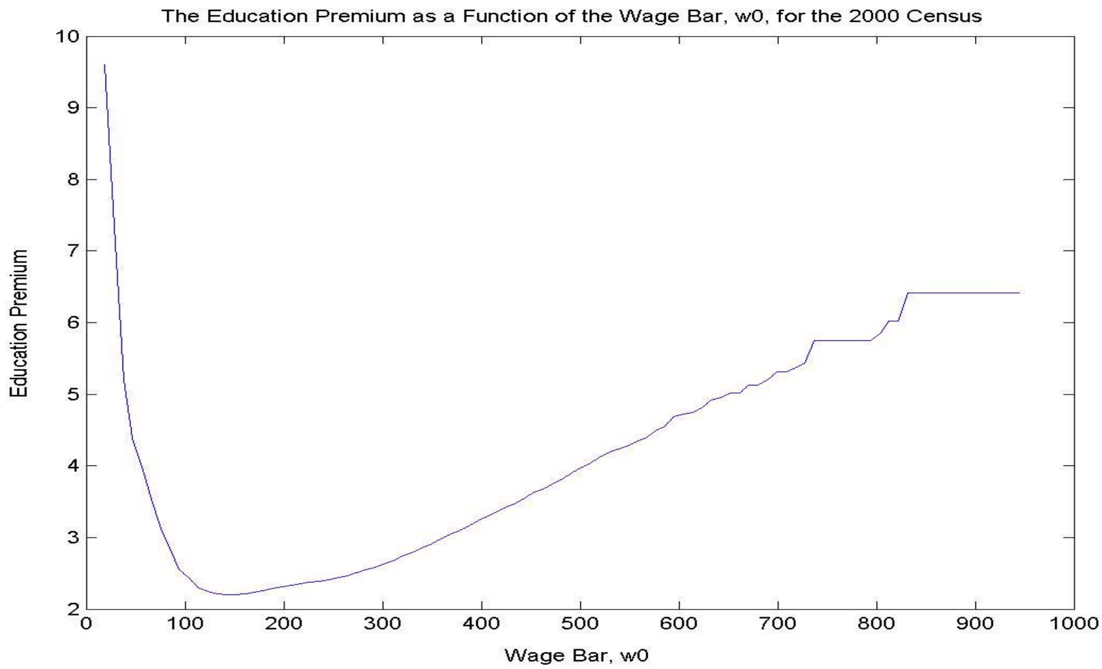
Suppose w_0 is high, so that N_L is high and N_H is low. Then the first term in the parentheses will tend to be small and the second term will tend to be large, making the derivative tend to be positive. The reverse will be true when w_0 is low. Conjecture 2 below formalizes this.

Conjecture 2 $\lim_{w_0\to\infty} \frac{\partial\left(\frac{W^H(w_0)}{W^L(w_0)}\right)}{\partial w_0} > 0,$ *and* $\lim_{w_0\to 0} \frac{\partial\left(\frac{W^H(w_0)}{W^L(w_0)}\right)}{\partial w_0} < 0$.

Proof Pending

Figure 1 below plots the education premium as a function of the wage bar, w_0, for the 2000 Census.[4] This is simply the ratio of the mean of all wages above the bar to the mean of all wages below the bar in the 2000 sample. Of course, this is a simplification of the actual premium, since not every worker with high education will earn more than every worker with low education. As the wage bar falls from its highest level, the premium falls and then rises, just as predicted. The lowest point of the premium is approximately reached at $w_0 = 132.3$, which is close to the mean wage for the whole population, \$147.35. At this point, 30.53% of the population is labeled "highly educated." About 31.18% of the 2000 Census had a college education or more, according to calculations in section III. Therefore, in 2000 the economy was around the point at which further increases in college education would cause the college premium to rise, if everyone gained education uniformly and education had no effect on the wage distribution.

[4] See section III for more about the data.



3 Simulation

The purpose of this section is to determine if the changes over time in the education premium and other wage statistics are consistent with the model, and if so, how much education levels changing over a fixed wage distribution can explain those statistics.

To do this, counterfactual statistics are created for the cases in which either the wage distribution does not change from one period to the next, or the distribution of education over wage ranks doesn't change. Since the model implies education would not affect the wage distribution, the distribution of wages and the distribution of education over wage ranks can be considered separately. One set of counterfactual statistics uses the previous period's wage distribution and the current period's education distribution, to determine what would have happened if the wage distribution didn't change at all (the "pure signaling" premium). The other uses current wages and the previous education distribution to determine what would have happened if education levels didn't change (the "wage changing" premium). If the pure signaling premium is close to the actual premium, it can explain much of the change in the premium, and likewise for the "wage changing" premium.

Let the distribution of wages in period t be $N_t(w)$, and an individual's wage rank in period t be given by $r = N_t(w)$. Let individuals be indexed by wage rank r, and the education level be denoted by $E_t^r \in H, L$ for high and low education for the individual with wage rank r in period t. Let the total population in period t be denoted as $R_t = N_t^H + N_t^L$, for the highest rank in period t. Thus the probability of an individual with wage rank r being highly educated in period t is $P(E_t^r = H)$.

The mean high education wage in period t is

$$W_t^H = \frac{1}{N_t^H} \int_0^{R_t} P(E_t^r = H) N_t^{-1}(r)\, dr \quad , \tag{11}$$

or, for a finite number of individuals $r \in (1, ..., R_t)$ in period t,

$$W_t^H = \frac{1}{N_t^H} \sum_{r=1}^{R_t} 1(E_t^r = H) N_t^{-1}(r) \quad . \tag{12}$$

Similarly,

$$W_t^L = \frac{1}{N_t^L} \sum_{r=1}^{R_t} 1(E_t^r = L) N_t^{-1}(r) \quad . \tag{13}$$

In the case S where education is pure signaling, the counterfactual mean high education wage, for periods t and τ, $\tau > t$, $W_\tau^{H,S}$, is

$$W_\tau^{H,S} = \frac{1}{N_\tau^H} \sum_{r=1}^{R_\tau} 1\left(E_\tau^r = H\right) N_t^{-1}\left(r\right) \tag{14}$$

so that the wage distribution, $N_t\left(w\right)$, is the same as in the previous period t, but the distribution of education across wage ranks, $1\left(E_\tau^r = H\right)$, is from the current period τ. Of course, R_t must equal R_τ. Similarly,

$$W_\tau^{L,S} = \frac{1}{N_\tau^L} \sum_{r=1}^{R_\tau} 1\left(E_\tau^r = L\right) N_t^{-1}\left(r\right) \tag{15}$$

with the education premium in the pure signaling case being $\frac{W_\tau^{H,S}}{W_\tau^{L,S}}$.

Other studies, including Juhn, Murphy, & Pierce (1993) and Card & DiNardo (2002), have shown that for many years the wage distribution has changed. In order to determine how much of the changes in the education premium were due to changes in the wage distribution, as opposed to changes in the education distribution, counterfactual premiums are calculated for the case where the wage distribution changes but not the education distribution. For the wage changing case, W,

$$W_\tau^{H,W} = \frac{1}{N_t^H} \sum_{r=1}^{R_t} 1\left(E_t^r = H\right) N_\tau^{-1}\left(r\right) \tag{16}$$

$$W_\tau^{L,W} = \frac{1}{N_t^L} \sum_{r=1}^{R_t} 1\left(E_t^r = H\right) N_\tau^{-1}\left(r\right) \tag{17}$$

and the premium for the wage changing case is $\frac{W_\tau^{H,W}}{W_\tau^{L,W}}$.

Above, it was discussed what the effects on the premium would be if all workers gained more education. However, in the data, increases in education do not always occur evenly across all wage ranks. Also, wages are not perfectly correlated with education: some very high wage workers can have low education, and vice versa. To figure out how this affects the premium, first consider workers in the middle of the wage distribution, those with wages inbetween the mean high and low education wages. If more of them move from being low educated to high educated, both high and low mean wages will fall, and the premium will act in the manner described in section II. At low quantities of high educated workers the premium will tend to fall, but at high levels it will tend to rise. But if workers who earned more than the mean high wage moved from being low to high educated, the mean high wage would rise, the mean low wage would fall, and the premium would rise. If workers who earned less than the mean low wage became highly educated, mean low education wages would rise, mean high education wages would fall, and the premium would fall.

As more and more people gain education, the definition of high education changes. The definition of "highly educated" most common in the current literature is a college graduate, but the definition more common early in the 20th century and before, as is noted in Goldin & Katz (1995), was a high school graduate. Each definition uses a different w_0 "bar," but in each case the number of highly educated individuals tends to rise over time (the "bar" falls). Therefore, the definition of high school graduate in this model would be a good prediction of the college graduate definition in a future where the number of college graduates had grown to the current level of high school graduates. Three different definitions of "highly educated" were used here in order to have a broader range of education quantities: (1) those with a college degree or more education; (2)

those with at least two years of college; (3) those with at least a high school education.

In general, the model predicts that in the pure signaling case under definition (1), both $W_t^{H,S}$ and $W_t^{L,S}$ would tend to fall over time as workers gain more education, with mean high education wages falling more than mean low education wages, so that the counterfactual pure signaling premium would fall. Under definition (3), there should be enough highly educated workers so that while both $W_t^{H,S}$ and $W_t^{L,S}$ would still fall, $W_t^{L,S}$ should fall more than $W_t^{H,S}$, and the counterfactual premium should rise. Definition (2) could act like either, depending on how many more high educated workers there were under this definition. This effect should explain a significant amount of the changes in the actual premiums, so that the counterfactual premiums should not be close to the actual premium in the previous period, but closer to the current actual premium.

U.S. census data from 1940-2000 from the IPUMS was used.[5] Incomes that were at the year's topcode were multiplied by 1.4.[6] All workers who reported less than 35 hours worked per week and/or less than 40 weeks per year were excluded. Also, workers who earned less than the minimum hourly wage were assumed to be misreported and excluded. While the first adjustment did not seem to alter the results significantly, the two exclusions do.[7]

[5] Data was obtained from the Integrated Public Use Microdata Series website, from the Minnesota Population Center at the University of Minnesota.

[6] This is similar to Katz & Murphy (1992) and Card and DiNardo (2002).

[7] The further below the minimum wage an individual is, the *more* likely they are to have attended college. This is interpreted to mean that the further below the minimum wage, the

For each census year, a sample of individuals was ranked according to hourly wage. Each individual was assigned a binary variable, 1 or 0, for $1(E_t^r = H)$. Two vectors were created for each census year, one for $1(E_t^r = H)$ and one vector of wages for $N_t^{-1}(r)$. The vectors were multiplied element by element and averaged to obtain the actual mean wages which were then divided to obtain actual education premiums. For the pure signaling counterfactuals, the $1(E_\tau^r = H)$ for the current year and $N_t^{-1}(r)$ wage vector for the previous census year was used, and vice versa for the wage counterfactuals. Also, counterfactuals were calculated using 1940 and 2000, to cover the whole period. The samples of individuals were randomly selected to be equal in number to the smaller adjacent census year, so that the vectors of comparison years would be of equal length even though IPUMS census samples have differing numbers of observations in different years. Therefore there is a slight randomness to the results. To minimize this, each statistic that uses two different census years is averaged over 3000 trials. The remaining variation does not change any of the qualitative results.

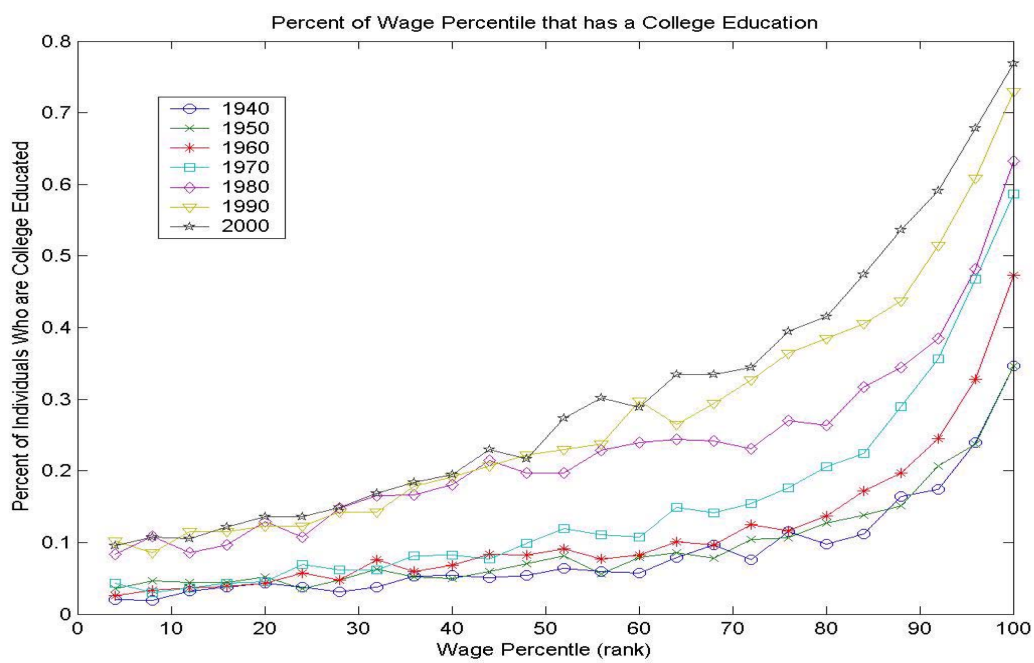
more reporting errors there are of people who should have been somewhere else in the wage spectrum.

Table 1: Statistics and Counterfactual Statistics Using College Educated as the Definition of Highly Educated

	Year							
	1940	1950	1960	1970	1980	1990	2000	1940-2000
Education Premium	1.55459	1.395	1.5334	1.6122	1.433	1.6552	1.8019	
"signaling" Premium		1.4704	1.4873	1.5676	1.4216	1.5085	1.6645	1.5114
"Wage" Premium		1.4625	1.4416	1.5723	1.6283	1.5616	1.7876	1.9021
Mean High wage, W^H	1.13991	2.1248	3.7756	6.2005	10.8106	19.4398	28.8356	
Mean Low wage, W^L	0.73326	1.5231	2.4622	3.8460	7.5438	11.7448	16.0032	
"signaling" High Wage $W^{H,S}$		1.1226	2.2384	3.7764	5.4413	11.0602	19.2526	1.0644
"signaling" Low Wage $W^{L,S}$		.7635	1.5050	2.4091	3.8276	7.3318	11.5667	.7042
% Highly Educated		.0951	.1154	.1500	.2300	.2734	.3118	
Std. Dev. of Log Wages	.4668	.3812	.4358	.4531	.4742	.575	.5920	

The results in Table 1 tend to confirm the model's predictions, with two important irregularities. For the entire period statistics, in the 1940-2000 column, the pure signaling effect would have caused the premium to fall, while the pure wage effect caused it to rise. The latter would be due to the increased variance in the wage distribution as shown in the standard deviation of log wages. This is consistent with the model's predictions when the number of highly educated is low, or less than 32% here. Both the pure signaling high and low mean wages fell, with the high wage falling more. Other studies, such as Katz & Murphy (1992), have also shown that an additional supply of college grads would have caused the premium to fall, but other factors caused the premium to rise (they call it a demand increase). Here, however, this effect can explained without the need for any real effects of education.

Decade by decade changes are more complicated. In the 1940s, the premium falls, due both to the signaling and wage effects. The wage effect can be explained by the fall in wage variance. As for the signaling effect, refer to figure 2 below. It displays the percentage of individuals in the census who are college educated for a given wage percentile (rank) for each census year, or $P\left(E_t^r = H\right)$ for H being college educated.



From figure **??**, in 1950, there were more low wage earners, while there was virtually no change for high wage earners. The counterfactual signaling mean college wage fell (it was lower than the actual 1940 mean college wage), while the counterfactual mean high school wage rose (it was higher than the actual 1940 mean high school wage), meaning more low wage earners gained a college education than high wage earners. In other words, the mean college wage fell and the mean high school wage rose because many low wage earners shifted to the college educated group. This counterintuitive shift may have been due to WWII and the GI bill.[8]

In the 1950s, there is an adjustment back to a more "normal" trend of education gain. The education premium rose, due to both effects, and the wage variance rose. From figure 2 it can be seen that high wage earners tended to gain more college education. This can also be seen in the rise in the signaling college wage above the 1950 actual college wage and the fall in the signaling high school wage from the 1950 actual wage. Thus, part of the premium rise is due simply to the fact that higher earning people were included in the college "label". The 1960s are similar to the 1950s.

The 1970s resemble the 40s more than the 50s and 60s. However, the wage premium in 1980 is higher than the actual 1970 premium, consistent with the increase in wage variance. The 1980 signaling premium is lower than the actual 1980 premium, making it the sole cause of the fall in the premium. Figure 2 shows a very large increase in the number of low and middle wage earners gaining

[8] The irregularities of the 1940s wage and educational changes and the effects of the war are studied in Goldin & Katz (1992).

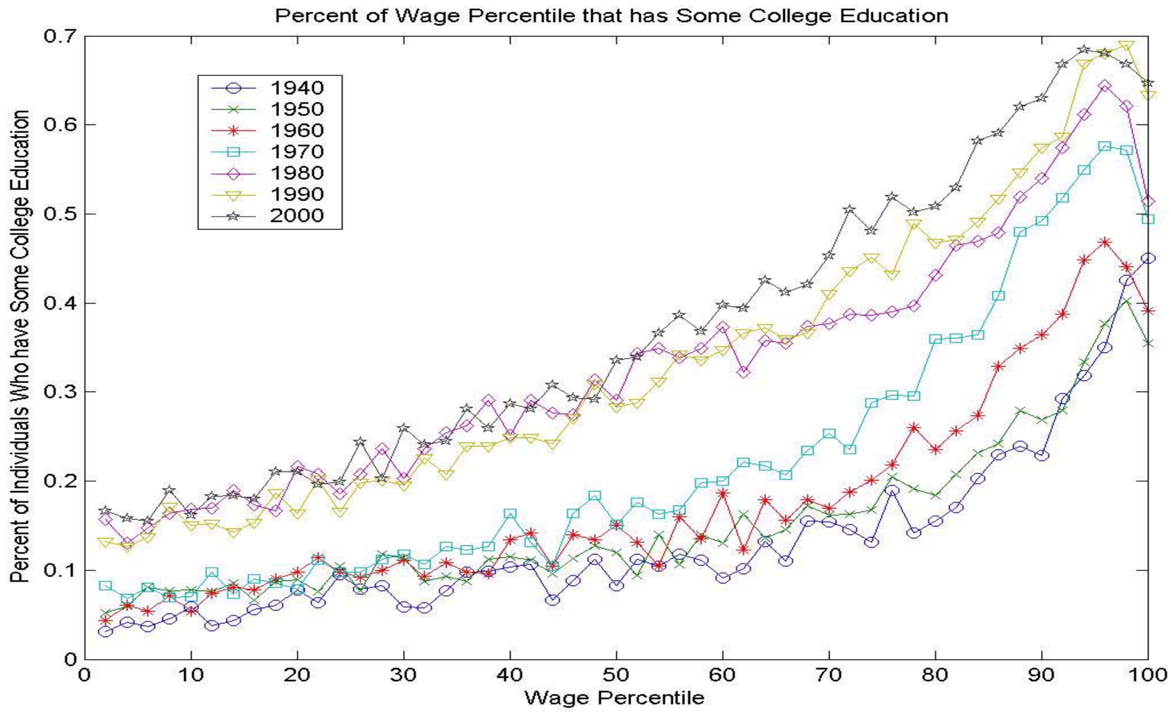
a college education, and both the signaling college and high school mean wages were below their previous actual levels. This could be due to the Vietnam War. The signaling wage changes imply that the model's predicted effects of education gains dominated: the signaling effect caused both mean wages to fall but the low education wage was affected more than the high wage. This is despite the fact that low wage earners gained relatively more education. The 80s and 90s act similarly to the 50s and 60s, perhaps as an adjustment to the 70s just as the 50s and 60s adjusted to the 40s.

In summary, although there were shocks in the 40s and 70s that disrupted the usual trends, the counterfactual premiums and wages acted over the entire period as the model would predict.

Table 2: Statistics and Counterfactuals Using Some College

Education as the Definition of Highly Educated

	Year							
	1940	1950	1960	1970	1980	1990	2000	1940-2000
Education Premium	1.46509	1.3283	1.4550	1.5153	1.3569	1.5579	1.6960	
"signaling" Premium		1.3872	1.4081	1.4784	1.3460	1.4361	1.5859	1.4572
"Wage" Premium		1.3895	1.3677	1.4877	1.5296	1.4603	1.6631	1.7549
Mean high wage, W^H	1.05495	1.9961	3.5119	5.6850	9.9914	18.0201	26.6377	
Mean Low wage, W^L	.72006	1.5028	2.4137	3.7518	7.3636	11.5671	15.7066	
"signaling" High Wage $W^{H,S}$		1.0430	2.0840	3.4791	5.0345	10.3894	18.0045	1.0077
"signaling" Low Wage $W^{L,S}$		0.7519	1.4800	2.3534	3.7403	7.2344	11.3527	.6915
% Highly Educated		.1571	.1822	.2314	.3545	.3537	.3913	.3913
Std. Dev. of Log Wages	.4668	.3812	.4358	.4531	.4742	.5551	.5920	

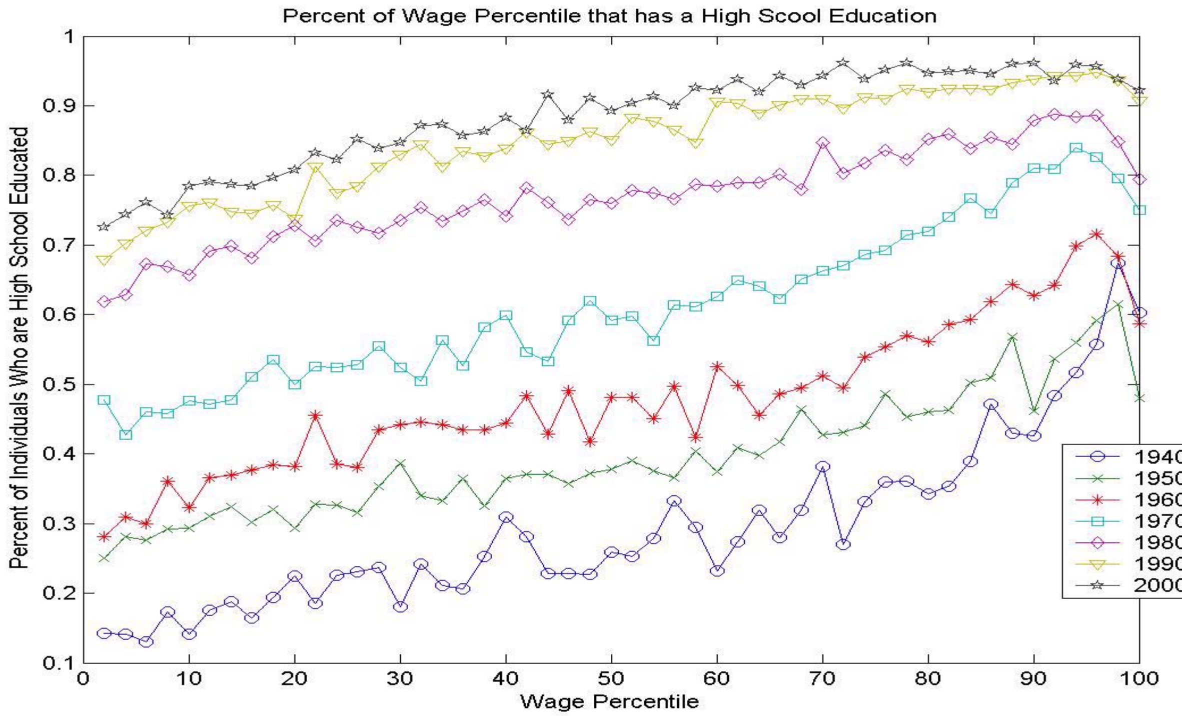


Definition (2) in table 2, those with some college as highly educated, acts almost the same as the college grads definition. The only exception is for the 1960s, where the signaling mean high education wage is lower than the actual 1950 mean wage. The fact that the 1970 signaling premium is also lower than the 1960 real premium is probably due an adjustment to the 40s, just as before, which made the signaling high wage fall by less than it normally would have. The reason the some college definition works similarly to the college definition is probably due to the fact that the some college definition is not more inclusive, with still only 39.13% of people highly educated in 2000 under this definition.

Table 3: Statistics and Counterfactuals Using High School

Educated as the Definition of Highly Educated

	Year							
	1940	1950	1960	1970	1980	1990	2000	1940-2000
Education Premium	1.19538	1.14824	1.2263	1.25084	1.20421	1.43468	1.57168	
"signaling" Premium		1.1750	1.1996	1.2338	1.1927	1.3459	1.5130	1.4187
"Wage" Premium		1.1673	1.1682	1.2426	1.2626	1.2553	1.4921	1.3519
Mean high wage, W^H	.84788	1.64744	2.77345	4.34577	8.15737	13.8286	20.0793	
Mean Low wage, W^H	.70930	1.43475	2.26097	3.47426	6.78617	9.63883	12.8008	
"signaling" High Wage $W^{H,S}$		0.8227	1.6709	2.7066	4.1812	8.2233	13.8952	0.7979
"signaling"Low Wage $W^{L,S}$		0.7002	1.3928	2.1938	3.5057	6.1097	9.1837	0.5625
% Highly Educated	0.4013	0.4792	0.5338	0.6641	0.8103	0.8674	0.8890	
Std. Dev. of Log Wages	.4668	.3812	.4358	.4531	.4742	.5551	.5920	



For definition (3) in table 3, where high school graduates are considered highly educated, the data is consistent with the model's predictions for high numbers of highly educated workers. The premium rises due to the wage effect, as the wage variance rises. But the premium also rises due to the signaling effect, as the signaling premium for 1940-2000 is higher than the 1940 actual premium. Both high and low education signaling mean wages fell from the 1940 actual levels, with the low mean wage falling further.

The 40s and 50s act similarly for the high school definition as for the college definition. The signaling effect lowered the premium in the 40s, and so did the wage effect as the wage variance fell. The signaling mean low education wage rose from the 1940 actual wage and the signaling mean high education wage fell from the 1940 actual wage. As can be seen in figure 4, low wage workers again attained relatively more education. The 50s acted as an adjustment, just as for the college definition. The 60s, however, see the signaling effect increase the premium, despite the fact that the signaling mean high education in 1970 wage fell from the 1960 actual wage. In that sense, the 60s acted as the model would predict when there are many highly educated workers. The premium falls over the 70s due entirely to the signaling effect, because once again low wage workers greatly increase in education, as can be seen in figure 4, and because the signaling mean high wage fell from the 1970 actual wage and mean low wage rose from the 1970 actual wage. This effect overcame the wage effect and the increase in the wage variance. The 80s and 90s again can be interpreted as in the college definition, as an adjustment to the changes of the 70s.

In summary, additional high school graduates tended to make the education premium rise as predicted, though the rise was bumpy due to the shocks of the 40s and 70s.

4 Conclusions

In an economy where education does not affect productivity and employers offers wages to equate wage rank and education rank, rising education by all workers will at first cause the education premium to fall, and then rise. The effects of a changing education distribution across wages can be seen to act this way in the 1940-2000 census years. If these trends continue, this effect could cause the relative price of a college education to actally rise with additional relative supply soon, as the percent of workers with a college education is close to what the percent of workers with a high school education was over the support of the census data. This could provide a testable implication of the signaling hypothesis: if the college education premium is seen to rise with additional supply, it would support the signaling model.

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