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Steffen Habermalz

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Steffen Habermalz
Marquette University and IZA Bonn

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IZA

P.O. Box 7240
D-53072 Bonn
Germany

Tel.: +49-228-3894-0
Fax: +49-228-3894-210
Email: iza@iza.org

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ABSTRACT

Job Matching and the Returns to Educational Signals*

This paper develops a multi-period model, in which workers are matched with jobs according to imperfect educational signals and in which their subsequent productivities depend on both their inherent ability and on the quality of the job match. It outlines a sequential process, in which underpaid employees reveal their true productivities and overpaid employees are detected by the firm until every match is perfect. The model produces a time path of the returns to educational signals that is concave, a feature that earlier studies used to dismiss educational signaling. Using a synthetic panel data set from the Current Population Survey the theoretical result is then substantiated empirically. The paper contributes to the literature by establishing the possibility of increasing returns to education over part of a workers life within the signaling framework theoretically and empirically.

JEL Classification: I20, J41, D8

Keywords: returns to education, signaling, job matching, information

Steffen Habermalz
Marquette University
Department of Economics
College of Business Administration
David Straz Hall 215
P.O. Box 1881
Milwaukee WI 53201
USA
Tel.: +1 414 288 3409
Email: steffen.habermalz@marquette.edu

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1 Introduction

Ever since the contributions of Spence (1973) and Arrow (1973) there has been considerable work in the human capital versus signaling debate. The theory of human capital as laid out by Becker (1964) and Mincer (1962) claims that education (and job training) add directly to a person's productivity and that innate ability is merely a foundation to build on. This approach has received widespread attention over the last 30 year and the empirical literature investigating the effect of schooling on earnings is huge.[1]

Within the signaling (or screening) framework developed by Spence, additional years of education have (in the extreme version of the theory) no effect on a individual's productivity.[2] Education serves as a signal of innate productivity to alleviate the informational asymmetry between the employer and the employee about the true productivity of a worker. It therefore solves the information problem introduced by Akerlof (1970). The crucial assumption within the signaling framework is that the cost of acquiring education is negatively correlated with innate productivity such that the more productive individuals will acquire more education. Therefore, the amount of education an individual acquires signals the individual's innate ability. In the absence of better information, employers use these educational signals to predict the true productivity of workers in the hiring process.

One way suggested to test for the existence of signaling focuses on the time path of the returns to educational signals. It has been suggested that returns to educational signals decline over time. The intuition behind this hypothesis is that employers learn about the true productivity of their employees over time, therefore causing the educational signal itself to be of lesser value. Layard and Psacharopoulos (1974) failed to find such a pattern and thus rejected the screenist view.[3] Riley (1979) argued that employers have to be right *on average* in predicting the true productivities of a group of workers. While some members of a particular educational signaling group will earn a higher wage and some will earn a lower wage, the return to an educational signal is constant over time. He uses this argument to dispute the hypothesis that returns to educational signals decline over time and questions the importance of the results of Layard and Psacharopoulos. Farber and Gibbons (1996) present a model that incorporates Riley's point. Their signaling model of employer learning fails to predict declining returns to an educational signal. Information gathered by the employer after hiring is orthogonal to the educational signal. In their model the driving assumption is that the productivity of a worker does not depend on the job match and is (in the absence of job training) constant over time. Belman and Heywood (1997) argue that the productivity of a worker in a particular job depends on the quality of the match between the requirements of the job and the abilities of the worker and is likely to increase over time due to better matching. In their framework workers acquire educational signals and are matched to jobs that require a specific level of productivity. However, a high productivity worker matched with a low productivity job will not be able to achieve his full productivity. He is constrained by the *quality* of the job match. Employers cannot immediately observe the true productivity of workers. Thus, the matching-process results in non-optimal matches in the first period. In the second (and last) period the true productivity of the new employees is revealed and mismatched workers are reassigned to appropriate jobs. The main feature of this process is that the average productivity of all workers improves from period one to period two.

Belman and Heywood calculate the return to an educational signal in each period to demonstrate that the return to an educational signal attenuates over time. The intuition behind their result is that there is improved matching in the second period but since higher level signals have less "room" to improve, the returns to educational signals declines.[4]

However, the question of how and when workers' true productivities are revealed is not given any attention. The model changes from a period in which nothing is known to a period in which there is perfect information about workers' true productivities.

This paper presents a multi-period model explicitly modeling the process in which worker productivities are revealed. Information in the first period is imperfect but symmetric (the worker not the employer has knowledge of the worker's true productivity). From period two onward the informational structure of the model changes. Workers become privately aware of their true productivity. Information becomes asymmetric between employers and employees because employers are still excluded from the knowledge of the true productivity of their workforce.

This approach offers a departure from the employer-learning hypothesis (Farber and Gibbons [1996], Altonji and Pierret [1998, 2001]) in two ways. First, the productivity of workers increases over time with better matches. Second, the behavior of both employers and employees is governed by their respective abilities to appropriate returns from creating information. Employers try to detect below average ability workers that are overpaid as a result of the imperfect matching process. It is assumed that newly created information becomes public instantaneously. Thus, employers have no incentive to gather information on underpaid high ability workers, who would be bid away by other firm without the opportunity to recover the detection costs. Consequently employees that are underpaid have to reveal their true productivity to be able to earn higher wages. The difficulty in appropriating returns to creating information is identified in Stiglitz (2002) as one of the key issues in information economics and thus seems to be the natural way to model behavior in the current context.[5]

The main result of the model is that the returns to educational signals actually show an increase over time in the early stages of the model.

Using a synthetic panel from the 1979-1998 Current Population Survey (CPS) the main hypothesis of the theoretical model is confirmed by looking at the time path of diploma effects. The regression results also suggest that the returns to an educational signal increase for a substantial part of an employee's work life.

The paper contributes to the literature because the concave time path of the returns to educational signals shows that finding increasing returns to educational signals empirically can no longer be interpreted as evidence against the signaling hypothesis.

Section two describes the matching and provides a detailed description of the revealing/detection process and its effect on the components of the model. The section concludes with the presentation of the main theoretical result. Section four describes the data set and contains the empirical results. Section five concludes and suggests directions for future research.

2 The model

Assume N ordered worker types consisting of equal numbers of workers, T_i, i= 1,2,3…N with productivities v_i ,i= 1,2,3…N. There also are N firm types, t_i, i= 1,2,3…N.

The job match determines the productivity of each worker. A worker matched with a job t_j has *maximum* productivity v_j even though his true productivity might be higher. His productivity is constrained by the job match. Workers who are assigned to a job t_i and have productivity v_j, with $i>j$, realize productivity v_j.

Each worker purchases an ordered educational signal S_i, $i=1,2,3\ldots N$. The model does not explicitly model the process in which agents acquire educational signals. However, it seems reasonable to assume that the acquisition of signal originates from a Spencian process in which agents observe their own productivity with noise and base the decisions about the acquisition of educational signals on unbiased estimates of their own productivity. This would result in signaling groups that potentially contain workers of all types and whose heterogeneity depends on the sampling distribution of the estimator used by the agents.

After the individuals obtained their respective signals every signaling group S_i contains workers of all true productivities. The parameter a measures the proportion of the workers who purchased a certain signal S_i and is of type T_i and thus is optimally matched. It is assumed that $a > 1/N$. This assumption is necessary to ensure that the educational signal has informational content.[6] The magnitude of a depends on the ability of individuals to estimate their true productivity. For simplicity I assume that workers who purchase a signal and are *not* of the corresponding productivity are represented in equal proportions in each signaling group. Thus the share of workers of any given productivity in a signaling group S_i that is *not* of true productivity v_i is $\frac{(1-a)}{N-1}$.

The model has N periods. In period 1 the firm j's profit maximizing choice is to hire workers that purchased the signal S_j. Therefore the first period wage in firm j is equal to the expected productivity of the group that purchased the signal S_j.

$$(1) \qquad wF_j^{t=1} = wS_j^{t=1} = a \cdot v_j + (1-a) \cdot \frac{1}{(N-1)} \cdot \left((N-j) \cdot v_j + \sum_{i=1}^{j-1} v_i \right) \text{ for all j}$$

The first term on the right side of equation 1 represents the share of workers who purchased the educational signal S_j and are of the true productivity v_j. The second term is an average of the productivities of the remaining N-1 groups, some of which are constrained by the job match. The first term inside the parenthesis shows the workers that are of higher productivity than v_j but are constrained by the job match. The second term represents the sum of productivities of the workers that are of productivity less than j. It is important to note that (1) also equals the wage to the educational *signal* S_j in period 1 because all members of signaling group S_j are working in firm F_j.

$$(2) \quad wF_j^{t=1} = wS_j^{t=1}$$

In the last period in which all true productivities are revealed and all matches are perfect the wage to Signal S_j is[7]

$$(3) \qquad wS_j^{t=T} = a \cdot v_j + \frac{(1-a)}{N-1} \cdot \sum_{\substack{i=1 \\ i \neq j}}^{N} v_i \text{, for all j.}$$

The first term represents the share of signaling group S_j that are of true productivity v_j and are working in firm F_j. The second term summarizes all other workers that belong to signaling group S_j but are of either higher or lower productivity than v_j. They have all been assigned to their optimal firm and earn wages equal to the respective marginal products.

Returns to educational signals are calculated as the difference between the wages to educational signals of two adjacent groups decline over time.

$$(4) \qquad \left(wS_j^{t=1} - wS_{j-1}^{t=1}\right) = RS_j^{t=1} > RS_{j-1}^{t=T} = \left(wS_j^{t=T} - wS_{j-1}^{t=T}\right)$$

This result is left unaltered when moving to a multi-period setting because the first and the last period do not change. The following sub-section describes the pattern that governs the behavior between those two stages in a multi-period setting.

2.1 The Revealing Process

In the analysis employers maximize profits and employees maximize utility. In the periods after the hiring is completed *both* employers and employees try to improve their position. It is assumed that in the first period workers are assigned into the jobs according to their educational signals, i.e. firms with jobs that require productivity v_2 will hire workers with signals equal to S_2. Since the group that purchased educational signal S_2 contains workers of all true productivities there will be perfect matches, undermatched workers (workers have higher productivity than the job requires) or overmatched workers (workers have lower productivities than the job requires).

The employees that are constrained by the job match (undermatched) have an incentive to move on to another job and try to reveal their true productivity. Employers have an incentive to "weed out" underachievers by detecting those employees that have a lower productivity than the job requires (overmatched). This implies that employers have to try to gather information on who the sub par performing workers are. On the other hand, workers who are constrained by the job match have to find ways of distinguishing themselves from the other workers. It is assumed that the most undermatched workers reveal their true productivity first and that the firm detects the most overmatched workers first. Other workers follow sequentially in the order of the extent of the mismatch. This particular revealing process can be intuitively explained. Consider, for example, the undermatched workers who have an incentive to reveal their true productivity. Their ability to do so depends on either (or both) of the following. The time at which they realize that they are underpaid and the means they possess to credibly reveal their productivity. It is sensible to assume that both abilities depend on the deviation of their true productivity from the productivity required by the job. This implies that the workers that are most "displaced" learn about their true productivity earlier and can make this information public. It should be noted that this does not keep two individuals who possess different educational signals from revealing their true productivity in the same period. It also implies that the model does not necessarily follow a cardinal time scale. A change from one period to another occurs whenever enough time has elapsed for a worker to be able to reveal his true productivity or be detected by the employer. Both types of workers (under/overmatched) that have revealed their true productivity (or where detected) move to their appropriate firms where the match is perfect. In addition to the theoretical considerations in Stiglitz (2002) empirical evidence on job matching supports the proposed mechanism. Bartel/Borjas (1981) and Mincer(1986, Part A) find that the wages of quitters (underpaid in the model) usually increase and that the wages of workers who get laid off (detected) usually decrease.

There are up to five distinct stages in the revealing/detection process that a particular educational signaling group can pass through over time. Groups themselves can be distinguishing by their relative level of education compared to the median level. However, in this paper I will focus on the groups with levels of education greater than the median level. Furthermore, the analysis concentrates on the period when workers first reveal their true productivity. The reason for this is twofold. First, groups with below-median education do not experience the increase in the returns their signal. Second, the increase in the returns to educational signals happens in the transition between the first two stages.[8] For example, the highest educational signaling group (S_N) experiences the increase during the transition between the first two periods of the model. The second highest educational signaling group (S_{N-1}) will experience this transition between the first two revealing/detection stages one period later. For simplicity I will focus on the group with the highest educational signal.

2.2 Firm Wages

The revealing/detection process generally will alter firm wages. In period one, without any information other than the educational signal, firms of type F_j will hire the workers with educational signal S_j and pay a wage equal to the expected productivity of the workers. The firms maximize expected productivity. For example, in a simple 4x4x4 case (4 firms, 4 time periods, 4 worker types) the wage in firm four would be

$$wF_4^{t=1} = a \cdot v_4 + \frac{(1-a)}{3} \cdot (v_1 + v_2 + v_3) \qquad (5)$$

The first term on the right hand side in both equations shows the share of workers that signaled S_j and actually is of true productivity v_j. The second term captures the workers that signaled S_j and whose true productivity is not equal to v_j. Note that none of the workers in firm F_4 is constrained by the job match. To illustrate the concept of a constraint worker one can look at the period one wage in firm F_1.

$$(5a)\quad wF_2^{t=1} = a \cdot v_2 + \frac{(1-a)}{3} \cdot (v_1 + v_2 + v_2)$$

Here, the last term contains unconstraint workers (v1) and workers with true productivity v3 and v4 that are constrained by the job match.

In period two the revealing/detection process will cause workers with true productivity v_4 to migrate from firm F_1 to firm F_4 and workers with true productivity v_1 to migrate from firm F_4 to firm F_1. After this process is completed the wages in firm F_4 in period two will be

$$(6)\qquad wF_4^{t=2} = a \cdot v_4 + \frac{(1-a)}{3} \cdot v_4 + \frac{(1-a)}{3} \cdot (v_2 + v_3)$$

The first component of the wage of firm one in period two are the workers that signaled productivity one and are of true productivity one. The second term of equation 6 shows the workers that signaled S_1 but whose true productivity is v_4. They were the most undermatched and revealed their true productivity in the second period. The remaining component is comprised of workers that signaled productivity S_4 and that are of true productivity v_2 or v_3.

The revealing/detection process changes the wage in firm F_4 in period two. The firm gets workers with true productivity v_4 and releases workers with true productivity v_1. Clearly, the wage for workers in firm F_4 will go up. The wages of other firms are unaffected in period 1 because those firms did not participate in the exchange of workers (F2 and F3) or are unchanged because of the job productivity constraint[9]. As a result there are two general equations for firm wages in the model. Wages for firms that are still unaffected by the revealing/detection process (and therefore haven't changed yet) are calculated according to

$$(7) \qquad wF_j^t = v_j - \frac{1-a}{N-1} \cdot \sum_{i=1}^{j-1} \left(v_j - v_i\right), \text{ for } j \le N - t + 1$$

which is, of course, merely a reformulation of equation 1. Firm wages for firms increased due to the revealing/detecting process can be written as

$$(8) \qquad wF_j^t = v_j - \frac{1-a}{N-1} \cdot \sum_{i=j-(N-t)}^{j-1} \left(v_j - v_i\right), \text{ for } j > N - t + 1$$

The intuition behind this formula is that the wage of a worker in firm F_j depends on the productivity of the optimal worker v_j (first term) and is negatively affected by differences in true productivity between the optimal group and all other types of workers that are retained by the firm at a particular stage of the model.

2.3 Wages to educational Signals

Note that in period one the wages to the educational signals are equal to the firm wages because all members of a particular signaling group S_j are in firm F_j, thus

$$(9) \qquad wF_j^{t=1} = wS_j^{t=1}$$

Starting in period two wages to educational signals that are affected by the revealing/detection process differ from firm wages. Staying within the 4x4x4 example used earlier the period 2 wage to the educational signal S_4 is

$$(10) \qquad wS_4^{t=2} = a \cdot wF_4^{t=2} + \frac{(1-a)}{3} \cdot wF_1^{t=2} + \frac{(1-a)}{3} \cdot wF_4^{t=2} + \frac{(1-a)}{3} \cdot wF_4^{t=2}$$

The first term on the right hand side captures the share of the group with the educational signal S_4 that is actually of true productivity v_4. These workers are still in firm F_4 in the second period and earn the firm F_4 wage. The second term represents the share of workers who signaled S_4 and whose true productivity is v_1. They were detected in the second period, migrated to firm F_1 and thus earn the firm F_1 wage. The last two terms correspond to the unrevealed workers in firm F_4 that have signaled S_4 and are of true productivity v_2 and v_3 respectively. Members of the two remaining signaling groups have not yet changed firms, which is why their wages paid to signals in period two are still equal to the firm wages in period two.

Equation 10 shows that changes to the wage to an educational signal have two sources. First, the wage to the educational signal changes because of changes in firm wages. The second source of change is a compositional effect. The wage to the educational signal will change if members of the signaling group change firms, holding constant the level of the firm wages. In general the wage to an educational signal Sj for above median ability workers can be written as

$$(11) \qquad wS_j^t = wF_j^t - \frac{1-a}{N-1} \cdot \sum_{i=1}^{j-(N-t+1)} \left(wF_j^t - wF_i^t \right)$$

$$\text{for } N - t + 1 < j < 2 \cdot (N - t + 1) \text{ and } j \geq t$$

The second term on the right hand side partially reflects the compositional effect on the wage to the educational signal. It depicts the influence of members migrating from firm F_j to firm of lower order (within the ordinal ranking of firms) which weighs negatively on the wage to the signal S_j and also reflects differences in firm wages.

2.4 Returns to Educational Signals

Returns to an educational signal are defined as the difference between the wages of two adjacent educational signaling groups at a given point in time.

$$(12) \qquad RS_j^t = wS_j^t - wS_{j-1}^t$$

The return to an above median ability educational signal between the first two stages of the model is most easily found by the decomposition shown in equation 13. Assume that members of the educational signaling group S_j enter the revealing/detection process in period t. The wage to the signal of educational signaling group S_{j-1} has not changed yet and the wage to the signal S_j in period t is the sum of its wage in period t-1 and the change caused by the revealing/detection process. This means that the wage to the signal can be written as the return to the educational signal S_j in period t-1 and a change term. This change term will determine the direction of change due to revealing/detection.

$$RS_j^t = wS_j^t - wS_{j-1}^t$$

$$= \left(wS_j^{t-1} + \Delta wS_j^t\right) - wS_{j-1}^t \qquad (13)$$

$$= RS_j^{t-1} + \Delta wS_j^t \qquad (wS_{j-1}^{t-1} = wS_{j-1}^t)$$

Proposition: The returns to educational signals between stages I and II increase for any formulation of differences in true productivities that preserves the order of revealing in the model and for $1/N < a < 1$.

Proof:: Equation 21 shows the return to an educational signal in stage II:

$$(14)\quad RS_j^t = \text{within stage I return} + \left(\frac{1-a}{N-1}\right)^2 \cdot \sum_{i=1}^{j-(N-t+1)} \left[\sum_{k=j-(N-t)}^{j-1} \left(v_j - v_k\right) - \sum_{m=1}^{i-1} \left(v_i - v_m\right) \right]$$

Note that in the period when a return to an educational signal is first affected by the revealing process j=N-t+2. This implies that j-(N-t+1)=1 for all groups in that period. Thus equation 14 for this period can be simplified to

$$(15) \quad \left(\frac{1-a}{N-1}\right)^2 \cdot \sum_{k=2}^{j-1}\left(v_j - v_k\right) > 0$$

This summation will unambiguously be positive. q.e.d

Intuitively, improved matching makes one group unambiguously better off relative to another group if the group of lower order does not improve their match. This is the case for each signaling group when they enter stage II. One could say the group has a first-mover advantage.

3 Empirical Results and Data

This section will test the theoretical model empirically within the framework of sheepskin (diploma) effects. Although sheepskin effects have been taken as evidence in favor of the signaling hypothesis an alternative explanation based on selection bias due to Chiswick (1973) should be mentioned. If those who acquire a higher educational signal are more efficient learners, estimation will result in diploma effects because education has a more profound effect on productivity for one group than the other. On the other hand, Frazis (2002) provides evidence that links diploma effects to signaling via a modified version of Spence's model in which individuals, similar to the current model, are initially unsure about their true ability. He also shows that Human Capital Theory is an unlikely candidate when it comes to explaining the existence of diploma effects – even in the presence of the selection bias mentioned above. Therefore, it seems reasonable to test the theoretical model by analyzing the time path of diploma effects.

After giving a brief review of the empirical literature on sheepskin (diploma) effects this section will first describe the Current Population Survey (CPS) data set used in the estimation process. It then presents regression results. The results confirm the main hypothesis of the theoretical model, namely that returns to educational signals follow a concave time pattern and suggest that they increase over a substantial portion of an individual's work life.

3.1 Review of Empirical Literature

Hungerford and Solon (1987) renewed the investigation of sheepskin effects (another word for diploma effects). Using Current Population Survey (CPS) data Hungerford and Solon estimated the returns to an educational signal using spline and step functions, which disentangle the returns to years of schooling from the returns of a diploma-year and allow for discontinuities at the diploma year. They use years of education and dummy variables for diploma years (12 years of education=High School, etc.) and find a significant sheepskin effect for college graduation in both specifications. They estimate the effect to be about 9%. Hungerford and Solon do not find a statistically significant sheepskin effect for High School graduation. A study by Belman and Heywood (1991) using the same data also finds no statistically significant sheepskin effect for a High School diploma and estimate the return to college graduation at 10%. Their study also suggests that diploma effects are higher for women and minorities. In another study Heywood (1994) concludes that diploma effects are more likely to be found in the non-union, private sector. Belman and Heywood (1997) also use the CPS data to test the hypothesis of their job matching/signaling model, which produces a declining pattern of returns to educational signals over time. Their empirical results confirm this pattern and they also show that the finding is not a mere vintage effect by creating multiple synthetic cohorts. Jaeger and Page

(1996) note that the estimates of diploma effects in earlier research might be biased because they did not use information on actual diplomas. This would be the case if the variable years of education is an imperfect predictor of actual diploma years. They confirm this by reporting that, for example, only 87% of the respondents with 16 years of education actually obtained a bachelors degree and that 14% of the recipients of a bachelor's degree took longer than 16 years. Using a matched sample of the 1991 and 1992 CPS with information on actual diplomas they reveal that prior estimates of the diploma effect are too low. Jaeger and Page also look at diploma effects across different population groups and conclude, contrary to the findings of Belman and Heywood (1991) that there exist little differences in the returns to an educational signal across different demographic groups.

3.2 Data

The estimation uses repeated cross-sections of the March outgoing rotation files of the CPS to construct a synthetic panel data set spanning the period from 1979-98. The data set was constructed from five years of cross-sectional CPS-data (1979, 1985, 1990, 1994, 1998). Individuals were selected by age in every year. The range of ages selected in the five years of the synthetic panel where selected to simulate a cohort.[10] According to the predictions of the theoretical model the panel focuses on the early part of an individuals work life. Observations with missing information on the variables used in the analysis were deleted. The final sample consists of 175,676 observations. Table 2 shows descriptive statistics. The data utilizes the best information possible for the construction of the degree variables. The CPS started reporting actual degrees in 1991. All preceding years (1979, 1985,

1990) use the usual proxies for the degrees. The actual categories used are High School, Associate/Bachelor and Professional (includes PhDs, law degrees, MDs etc.).

3.3 Regression Analysis

The defining feature of the theoretical model in section 2 is that the returns to educational signal for above median groups first rise and then fall - their path over work experience is non-linear and concave. Earlier work on sheepskin effects did not derive this result and thus did not allow for it in the empirical analysis. For example, Farber and Gibbons (1996) find that in a theoretical model without productivity constraints and thus without a rise in average productivity over time, the returns to the educational signal should be constant over time. In the empirical model they test for this implication by adding an interaction term between years of education and experience to their wage equation. While this specification allows for either increasing or decreasing returns to educational signals over time it clearly does not allow for both at different stages of the model. A linearization of the time path of the returns to educational signals might lead to the conclusion that the time path is flat disguising the true concavity because positive deviations in the beginning might offset the negative deviations later.

The regression equation analyzed in this paper will allow for a non-linear time path for the returns to educational signals. It will be estimated with interaction terms between diploma-dummies and experience *and* between diplomas-dummies and experience squared. Diplomas were combined into three groups: High School (individual has only a High School diploma=HIGH), Associate-Bachelor (individual has a Bachelor/Associates as the highest degree=ASBA) and professional degrees (PhD, MD etc. as the highest degree=PROF). The basic formulation of the model is:

$$\begin{aligned}\ln wage = {} & b_0 + b_1 \cdot edu + b_2 \cdot ex + b_3 \cdot ex^2 \\ & + b_4 \cdot high + b_5 \cdot (high \cdot ex) + b_6 \cdot (high \cdot ex^2) \\ & + b_7 \cdot asba \cdot + b_8 \cdot (asba \cdot ex) + b_9 \cdot (asba \cdot ex^2) \qquad (16) \\ & + b_{10} \cdot pro + b_{11} \cdot (pro \cdot ex) + b_{12} \cdot (pro \cdot ex^2) \\ & + othercontrols + e_i\end{aligned}$$

The maintained hypothesis is that the coefficients on the interaction between the diploma dummy and experience are positive and the coefficients on the interaction between the diploma dummy and the square of experience are negative. The equation also includes years of education, experience and experience squared to control for the usual human capital effects on earnings. Other controls are: marital status, race, gender, part-time, an interaction between part-time and marital status, regional dummies and year dummies.

One could argue that the specification given in equation 16 does not mimic the theoretical model enough to give reliable estimates. Specifically, the theoretical model compares the returns to adjacent signals and the current regression specification compares the returns to a signal with the return to the lowest signal (base group). While this is true it should pose no problem for the estimation process. The "base" group in the empirical model contains all below median educational signals. While the return to the highest vs. the lowest educational signal is positive only if one makes further assumptions about the distribution of true productivities, the return of the highest signals vs. an average of all below median signals is certainly positive.

It should also be noted here that the inclusion of an experience variable doesn't necessarily follow from human capital theory but can be given a broader interpretation. The results of the theoretical model are not dependent on the existence of human capital and its accumulation. Thus the experience variable can be interpreted more broadly as a measure of time-spent working (in the labor market).

Table 1 shows the results of different regression specifications. The first five columns (model 1) estimate diploma effects by breaking up the synthetic panel by years. The results for the associate/bachelor group and the professional group are in line with the predictions of the theoretical model. Diploma effects first increase and then decrease in later year. The High School group shows a different picture. However, the High School diploma clearly does not qualify as an above median educational signal and thus is not predicted to have the hypothesized time path. Model 2 in utilizes the time dimension of the data and estimates the model presented in equation 16 without any further controls. The results indicate a concave time path of the diploma effects and confirm the main hypothesis. Changing returns to education over time could drive the results of the repeated cross-section and model 2. Therefore, model 3 is estimated with year dummies. The results in column 7 indicate that the addition of year dummies merely changes the quantitative but not the qualitative outcome of the estimation. Model 4 adds the remaining controls and also confirms the main hypothesis. The interaction terms between the diploma and potential experience are positive and statistically significant and coefficients on the second interaction term are negative and statistically significant. Figure 1 shows a simulation of the combined effect of the three coefficients for the Associate/Bachelor degrees form model 4 and traces out nicely the concave time path. It also suggests that the return to educational signal potentially increase over a substantial portion of an employee's work life.

Table 3 shows the diploma effects estimated in model 4 evaluated at mean potential experience and can be used to compare the sheepskin effects found in the sample to earlier studies. The results differ from earlier studies and are more in line with those of the more recent study by Jaeger and Page because they indicate a positive diploma effect of a High School degree. Jaeger and Page estimate a 10% diploma effect of High School graduation. Like them this study doesn't net out the negative effect of including individuals with a GED that would arises because individuals with a GED seem to be more similar to High School drop-outs than to individuals with a High School diploma as reported by Cameron and Heckman (1993). The results for the Associates/Bachelors degrees (38%) and Professional degrees (50%) also fall in the range of Jaeger and Page's study. Some of the differences arise because this study focuses on the time path of these effects and "lumps" diplomas together as opposed to estimating a different effect for, i.e. professional degrees and PhDs. Overall the results compare nicely with those of Jaeger and Page who also use actual diploma effects and potential experience.

4 Conclusion

The primary goal of this study was to provide additional insight in the debate over signaling and diploma effects. It was shown that when the mechanism by which below average are detected or above average workers reveal their true productivity is explicitly modeled the regular assumption that the return to an educational signal declines over time has to be generalized. The main result of the model is that for above median ability workers returns to educational signals first increase and then decrease.

Using a synthetic panel data set from the 1979-98 Current Population Survey (CPS) a regression model is used to test the main hypothesis of the theoretical model within the framework of sheepskin effects. The estimation focuses on diploma effects and allows for them to vary in a non-linear fashion over time. The results confirm the main hypothesis as they show a first increasing and then decreasing pattern of the returns to an educational signal over time and were shown to be robust to changes in specification.

The results contribute to the existing literature in at least two ways. First, it emphasizes that one cannot reject the signaling hypothesis merely because the return to educational signals does not decline. Second, it was shown empirically that the return to an educational signal increases for a large portion of an individuals work life. Still remaining is the need to confirm the productivity effect of quality of the match between workers and firms.

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Table 1: OLS-Estimation (robust)*

(Dependent variable: Log hourly wage)

	Model 1					Model 2	Model 3	Model 4
	1979	1985	1990	1994	1998	79-98	79-98	79-98
Education	0.048	0.083	0.084	0.084	0.086	0.056	0.067	0.069
	(15.31)	(32.29)	(31.27)	(30.28)	(31.50)	(40.85)	(46.54)	(50.48)
Experience	0.082	0.062	0.036	0.009	-0.024	0.031	0.057	0.036
	(21.33)	(20.30)	(8.52)	(1.31)	-(2.52)	(22.28)	(34.68)	(22.47)
Exp. squared	-0.005	-0.001	-0.001	0.000	0.001	-0.001	-0.001	-0.001
	-(8.15)	-(5.75)	-(3.70)	(1.37)	(3.63)	-(11.96)	-(17.99)	-(10.19)
High School (HIGH	0.081	0.065	0.034	0.070	0.067	0.051	0.047	-0.012
	(8.93)	(6.23)	(3.03)	(5.64)	(5.23)	(7.06)	(6.42)	-(1.75)
HIGH x experience	-	-	-	-	-	0.004	0.012	0.017
	-	-	-	-	-	(2.97)	(8.14)	(11.97)
HIGH x exp. square	-	-	-	-	-	0.000	-0.001	-0.001
	-	-	-	-	-	-(1.45)	-(8.21)	-(9.58)
Associate/Bachelor	0.117	0.159	0.163	0.236	0.218	0.148	0.185	0.100
	(5.14)	(9.38)	(8.83)	(13.46)	(12.18)	(14.98)	(18.67)	(10.35)
ASBA x experience	-	-	-	-	-	0.029	0.038	0.040
	-	-	-	-	-	(17.15)	(22.26)	(24.68)
ASBA x exp. square	-	-	-	-	-	-0.001	-0.002	-0.002
	-	-	-	-	-	-(13.85)	-(22.62)	-(21.44)
Professional (PROF	0.125	0.168	0.133	0.339	0.310	0.085	0.139	0.058
	(2.79)	(7.82)	(5.79)	(14.55)	(13.13)	(5.92)	(9.52)	(4.10)
PROF x experience	-	-	-	-	-	0.064	0.070	0.063
	-	-	-	-	-	(20.28)	(21.83)	(20.37)
PROF x exp. square	-	-	-	-	-	-0.002	-0.003	-0.003
	-	-	-	-	-	-(12.90)	-(17.24)	-(13.92)
R^2	0.2433	0.2425	0.2839	0.2577	0.2824	0.2226	0.2283	0.308
# obs.	21147	38369	43159	38724	34277	175676	175676	175676

* t-values in parentheses. Model 1 estimates the synthetic panel for each year seperately using all other controls. Model 2 estimates the synthetic panel without any controls. Model 3 adds year dummies to the specification in model 2. Model 4 adds all other contols to model 3. Other controls are: part-time, interaction between part-time and married, married, regional dummies gender and race.

Table 2: Descriptive Statistics

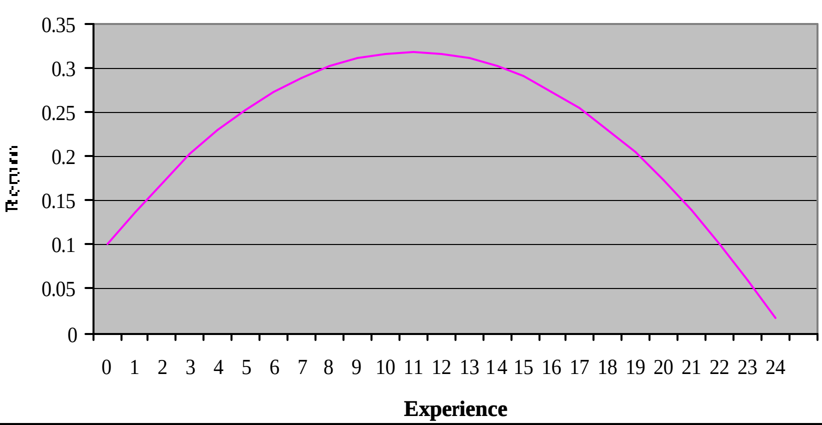
Variable	mean	std
Wage	1038.54	960.19
Real Wage	7.80	6.20
Log Wage	1.90	0.55
Education	13.32	2.35
HIGH	0.60	0.49
ASBA	0.21	0.41
PROF	0.07	0.26
Gender	0.52	0.50
Married	0.55	0.50
Part-Time	0.19	0.39
partmar	0.10	0.30
Black	0.09	0.29
Other Race	0.04	0.20
Age	29.76	6.14
Experience	10.47	6.19

Table 3: Diploma Effects*

high	0.10
asba	0.38
prof	0.50

*Effects estimated using OLS coefficient estimates and mean potential experience

Figure 1: Simulated Returns - ASBA



Endnotes:

[1] For a survey of the literature investigating the effect of human capital accumulation on earnings see Rosen, S. (1977), for a survey on more recent literature Card, D.(1999).

[2] For a model in which education does increase productivity see Spence (2002).

[3] For earlier work testing the signaling hypothesis see Taubman and Wales (1973), Wolpin (1977).

[4] Although most of the work cited dates back to, at least, the last decade there is still a considerable amount of work done in the signaling vs. human capital debate. For recent examples see, Dupray (2001), Bedard (2001), Riley (2002), Frazis (2002) or Spence (2002).

[5] He writes: "Someone who knows his abilities are above average has an incentive to convince his potential employer of that, but a worker at the bottom of the ability distribution has an equally strong incentive to keep the information private." Stiglitz (2002, page 463.)

[6] Consider picking a worker with educational signal High School. A share smaller or equal to $1/N$ would imply that it is more likely/equally likely that the worker you picked is not of true productivity High School and the signal would contain no information.

[7] Note that equation (2) is the wage to the signal since all worker types work in different firms, are perfectly matched and earn a wage that equals their true marginal product.

[8] For a complete description of the model see Habermalz (2002).

[9] Note that the firm wage in firm F_1 never changes.

[10] The range of ages are 1979 (16-22), 1985 (22-28), 1990 (26-33), 1994 (30-37), 1998 (34-41).

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