A SIGNALLING EXPLANATION FOR SENIORITY BASED PROMOTIONS

AND OTHER LABOR MARKET PUZZLES

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ABSTRACT

A worker's current employer will typically possess information concerning that worker's productivity which is not directly available to other potential employers. Recent papers have considered this problem and argued that in such a setting these other firms will utilize the actions of the current employer as signals of productivity. In this paper I demonstrate how this perspective can explain the existence of a number of labor market puzzles including: (i) why seniority is a factor in the promotion decision even after controlling for the effect seniority may have on productivity; (ii) why within a job category wages may rise with seniority even when productivity does not; and (iii) why within a job category wages may rise with education even when productivity does not.

I. INTRODUCTION

A recurrent theme in the labor economics literature is the extent to which labor market practices seem to deviate from the predictions of standard labor market theory. An important early study along these lines is the analysis of Doeringer and Piore (1971) concerning internal labor markets where it is argued, for example, that in actual labor market settings wage rates tend to be more closely associated with task assignments than with ability levels. More recently, both Medoff and Abraham (1980) and Baker, Jensen and Murphy (1988) have also questioned the validity of traditional theory on the basis of practices which seem puzzling to those schooled in the standard framework. In response to this questioning of received theory, an extensive literature has developed which demonstrates that many of these puzzling practices can in fact be understood by considering richer versions of standard theoretical models. Contributions to this literature include Lazear (1979) which provides an explanation for the practice of mandatory retirement, the analysis of Lazear and Rosen (1981) concerning labor market tournaments, and the recent analysis of Holmstrom and Milgrom (1990) concerning the multi-task principal-agent problem. In this paper I attempt to contribute to this literature by investigating the extent to which "third party signalling" can explain a variety of labor market puzzles.

Many labor market settings exhibit the feature that a worker's current employer possesses information concerning that worker's productivity which is not directly available to other potential employers. A number of recent papers have considered this idea and argued that these other firms will utilize the actions of the current employer as signals of the worker's productivity, i.e., the market will be characterized by what I refer to above

as third party signalling. For example, in Waldman (1984a) I explore how other firms can partially infer a worker's productivity by considering his task assignment, while Gibbons and Katz (1989) explore the difference in terms of third party signalling between a worker who is laid off and one who loses his job in a plant closing.[1]

One of the results of my earlier analysis is that the third party signalling approach provides an explanation for why wage rates tend to be more closely associated with task assignments than with ability levels. The logic is simple. Consider an environment where a worker's ability level is not directly observable by other firms, but the worker's task assignment is. In such an environment the wage offers of other firms will be more closely associated with the worker's task assignment than with his ability level, which in many cases will translate into actual wage rates being more closely associated with tasks than with ability levels.

My earlier analysis considered a two period framework. In this paper I extend that analysis by studying what happens in the presence of third party signalling when workers are modeled as being in the labor market more than two periods. Through this extension, I show that the third party signalling approach can explain a number of other labor market puzzles including: (i) why seniority is a factor in the promotion decision even after controlling for the effect seniority may have on productivity; (ii) why within a job category wages may rise with seniority even when productivity does not; and (iii) why within a job category wages may rise with education even when productivity does not.

Since the seminal contribution of Spence (1973), considerable attention has been paid to the role of signalling in the labor market. Most of this

literature has followed Spence's initial formulation concerning the process by which signalling works. In that formulation it is the worker who has private information concerning his own ability, and in choosing his behavior, e.g., his schooling level, the worker attempts to signal that he is of high ability. The point of this paper and my earlier one is that a different type of signalling also provides important insights into how labor markets operate. In the alternative formulation it is a worker's current employer who has private information concerning the worker's ability, and in choosing its actions the firm attempts to signal that the worker is of low ability. The reason the firm acts in this manner is that by signalling that the worker is of low ability the firm decreases the wages which it will need to pay the worker in future periods.[2]

This paper builds on the analysis of Bernhardt (1990) which also considers a multi-period extension of my earlier paper. There are three major differences between the papers. First, I more fully characterize the equilibrium as regards the importance of seniority in the promotion process. Second, the two papers employ different assumptions concerning how wage rates are determined for older workers, and this is important for the explanation of the puzzles concerning the relationship between wage rates and productivity. Third, following my earlier analysis, Bernhardt emphasizes the role of specific human capital for providing firms with a positive incentive to promote workers in the presence of third party signalling. Because here I employ a different assumption concerning how wage rates are determined for older workers, the current analysis does not require specific human capital for firms to have a positive incentive to promote workers.

II. A THEORY OF SENIORITY BASED PROMOTIONS

A recurrent theme in descriptive discussions of the labor market is the importance of seniority in the promotion process. Doeringer and Piore (1971), Mincer (1974) and Edwards (1979) all suggest that seniority enters into the promotion process even after controlling for the effect which seniority may have on productivity. In this section I show that the third party signalling approach provides a simple and intuitive explanation for this phenomenon. Consider an environment where seniority is a factor in the promotion decision because of a direct effect which seniority has on productivity. In such an environment potential employers will infer that workers with less seniority are promoted only when innate ability is especially high, and thus promoted workers will receive wage offers from these potential employers which increase as the seniority of the worker at the date of promotion decreases. The result is that since a worker's current employer would prefer to pay the worker less rather than more, the firm biases the promotion process against low seniority workers to an extent greater than that suggested by the direct effect which seniority has on productivity.[3]

A) The Model

Within the economy there is only one good produced and the price of this good is normalized to one. Workers are in the labor market for N+1 periods, and in each period labor supply is perfectly inelastic and fixed at one unit for each worker. Workers and firms are risk neutral, have a discount factor equal to β, and there is free entry into production.

Individuals display no disutility for effort. However, each worker has associated with him or her a value for a variable that will be called ability

and will be denoted θ_i for worker i. Each worker's value for θ is a random draw from a distribution described by a probability density function $h(\theta)$, where $h(\theta)$ is positive for $\underline{\theta} \leq \theta \leq \bar{\theta}$ and zero elsewhere.

Output can be produced by the performance of either of two tasks, where workers are indifferent between the performance of the two tasks. The first task is referred to as the skilled task while the second is referred to as the unskilled task. If worker i with total labor market experience j is assigned to the unskilled task then his productivity equals $x+\delta\theta_i$, $0<\delta<1$, while if he is assigned to the skilled task then productivity equals $f(j)+\theta_i$, $f'>0$, $f''<0$. That is, in the unskilled task productivity is only a function of ability but in the skilled task productivity depends both on ability and total labor market experience. Further, an increase in ability has a bigger impact on productivity in the skilled task than in the unskilled task. It is assumed that $x>f(N)+(1-\delta)E(\theta)$, $x<f(0)+(1-\delta)\bar{\theta}$, and $\beta f(N)>f(N-1)$. The first two assumptions tell us that for any fixed level of labor market experience the average worker is more productive in the unskilled task but high ability workers are more productive in the skilled task. The third assumption places a lower bound on the amount of managerial human capital accumulated in a worker's next to last period of labor market experience.

Before a worker's first period of employment, the individual's ability is unknown both to the individual and to all the firms in the economy. After a worker has one period of experience at a firm, the firm learns the worker's value for θ. It is assumed that firms other than the current employer never directly observe a worker's θ, but as will become clear some inferences can be made by observing the worker's past task assignments. It is also assumed that if a worker switches firms, then the previous employer "forgets" the worker's

value for θ. This assumption rules out the possibility of two or more firms simultaneously knowing a worker's θ. My conjecture is that on a qualitative level the results of the analysis do not depend on this assumption. However, the case where two or more firms can simultaneously know a worker's θ is mathematically much more complex and is beyond the scope of the current paper.

The analysis will focus on spot or one period contracts. Following Lazear (1986), Milgrom and Oster (1987) and Waldman (1990), it is assumed that this is an environment where a worker's current employer has the opportunity to make counter-offers. That is, at the end of each period other than a worker's last one, firms other than the current employer have an opportunity to specify wage rate/task assignment pairs for the following period. This is then followed by the current employer having an opportunity to make a wage rate/task assignment counter-offer. It is also assumed that in each period all of a worker's previous task assignments are public information.[4]

B) <u>Analysis</u>

As in many signalling games, the above model exhibits multiple equilibria. In the analysis I focus on the unique sequential equilibrium characterized by the following two properties (see Kreps and Wilson (1982) for the definition of a sequential equilibrium). First, because in actual labor market settings demotions are relatively rare, the first property is that there are no demotions in equilibrium. The second property concerns the beliefs of the other potential employers about a worker's value for θ when a worker's current employer takes an action which is "off the equilibrium path." In a sequential equilibrium beliefs on the equilibrium path are determined by application of Bayes' rule, but for off the equilibrium path beliefs Bayes' rule provides no guidance. It is well understood this is a

major reason why signalling and other types of games frequently display multiple sequential equilibria. In order to focus on the equilibrium which I believe is the most plausible equilibrium for the model, I place the following restriction on off the equilibrium path beliefs. That is, after an off the equilibrium path action the belief of other potential employers concerning a worker's lowest possible value for θ is bounded by the beliefs held by these firms at earlier dates. For example, if after the worker's third period of employment these firms believed that the worker's highest possible value for θ was equal to $\theta' < \bar{\theta}$, then at no future date could these firms believe that the lowest possible value for θ was equal to $\bar{\theta}$. Another way to put this assumption is that an off the equilibrium path action does not cause potential employers to revise their interpretations of previous moves which were on the equilibrium path. An equilibrium which satisfies this property might be referred to as a subgame perfect sequential equilibrium. The reason is that any equilibrium which satisfies this property will also have the property that every proper subgame of the game will be characterized by a sequential equilibrium.

An alternative approach which would yield the same equilibrium would be to perturb the game slightly in terms of the learning process. For example, suppose that instead of the current employer learning a worker's ability with probability one after a single period of employment, assume that after each period of employment there is a probability $(1-\delta)$ the current employer observes the worker's ability and a probability δ the firm observes nothing concerning the worker's ability, $\delta > 0$. For this perturbed model there is a unique sequential equilibrium which does not exhibit demotions, and the equilibrium we focus on is the limit of this equilibrium as δ approaches 0.

The unique sequential equilibrium which satisfies the two properties discussed above exhibits no turnover. Further, because there is no turnover,

in equilibrium it is always the case that total labor market experience equals seniority. In describing equilibrium behavior I will thus employ the term seniority to refer both to a worker's seniority and his total labor market experience.[5] In this equilibrium it is also the case that for a worker of seniority n the promotion rule is described by a value $\bar{\theta}^n$. That is, a worker with seniority n is assigned to the skilled (unskilled) task if $\theta_i > (<) \bar{\theta}^n$. $\bar{\theta}^n$ will be referred to as the promotion standard for seniority n. It should also be clear that a worker with seniority 0 will always be assigned to the unskilled task. Hence, the propositions focus on what happens when seniority is greater than 0.

Before proceeding some additional notation is required. $\hat{\theta}^n$ will denote the ability level of a worker with seniority n who is equally productive in the skilled and unskilled tasks, i.e., $x + \delta\hat{\theta}^n = f(n) + \hat{\theta}^n$. Note that $f' > 0$ implies $\hat{\theta}^n < \hat{\theta}^{n'}$ for $n > n'$. $W(\theta_i, n)$ will denote the wage paid to a worker of ability level θ_i and seniority n. $\psi(\theta_i, n)$ denotes the productivity of a worker of ability level θ_i and seniority n given that he is assigned to the task which maximizes his output, i.e., $\psi(\theta_i, n) = \max\{x + \delta\theta_i, f(n) + \theta_i\}$. We begin by establishing a benchmark with which later results can be compared. All proofs are in the Appendix.[6]

Proposition 1: Suppose after one period of experience in the labor market, rather than only being directly revealed to the current employer, the worker's ability level becomes public information. Then,

   i) $W(\theta_i, n) = \psi(\theta_i, n)$ for all θ_i, n pairs, where $n > 0$
   ii) $\bar{\theta}^n = \hat{\theta}^n$ for all $n > 0$.

Proposition 1 indicates that when information about a worker's ability level is directly revealed to other firms, the model is not consistent with descriptive discussions of the promotion process.[7] First, wage rates are associated with ability levels rather than task assignments. Second, each worker faces a promotion standard which only depends on the worker's relative productivities across the two tasks, i.e., seniority only affects the promotion standard to the extent it affects the worker's productivity at the skilled task.

These results are not very surprising. In this model once a worker's ability level becomes public knowledge, competition causes the individual's wage to be bid up to his productivity level. Hence, wages are associated with ability levels rather than task assignments. In addition, in the absence of asymmetric information there is no reason why a worker whose ability level is known should be assigned to anything other than the task which maximizes his output.

The labor market is typically not characterized, however, by information about worker abilities being revealed in a public manner. Rather, the more common case is that a worker's current employer has better information than do other potential employers, and other firms learn indirectly by observing the actions of the current employer, i.e., other firms learn through what we have termed third party signalling. In order to capture this case, we now assume that information is only directly revealed to a worker's current employer, but other firms do get to observe past task assignments.

<u>Proposition 2</u>: Suppose after one period of experience at a firm the worker's ability level is only directly revealed to the current employer. Then there exists a value n^*, $1 \leq n^* \leq N$, such that

   i) $W(\theta_i, n) = \psi(\theta, n)$ for all θ_i, n pairs, where $\theta_i < \tilde{\theta}^{n-1}$ and $n \geq 1$

   ii) $W(\theta_i, n) = \psi(\tilde{\theta}^{n'}, n)$ for all θ_i, n, n' triplets, where $\tilde{\theta}^{n'} < \theta_i < \tilde{\theta}^{n'-1}$

      and $1 \leq n' < n$

   iii) $\tilde{\theta}^N < \tilde{\theta}^{N-1} < \ldots \tilde{\theta}^{n^*} < \tilde{\theta}^{n^*-1} = \tilde{\theta}^{n^*-2} = \ldots \tilde{\theta}^0 = \tilde{\theta}$

   iv) $\tilde{\theta}^n > \hat{\theta}^n$ for all $1 \leq n \leq N-1$ $(\tilde{\theta}^N = \hat{\theta}^N)$

   v) $[f(n) + \tilde{\theta}^n - (x + \delta\tilde{\theta}^n)] - [f(n') + \tilde{\theta}^{n'} - (x + \delta\tilde{\theta}^{n'})] > 0$ for all n, n' pairs,

      where $n^* \leq n < n'$.

In Proposition 2 we introduce asymmetric information in such a way that for workers of seniority greater than 1, firms other than the current employer use a worker's previous task assignments as signals of the worker's ability. The introduction of such third party signalling results in an equilibrium more consistent with descriptive discussions of the labor market. First, i) and ii) indicate that wages are now more closely associated with task assignments than with ability levels. Consider two workers of the same seniority but different abilities. The two workers are paid the same wage if they have the same task assignment and their initial promotion (if they had one) occurred when they had the same level of seniority. In other words, as long as the two workers are associated with the same set of signals, the two workers receive the same wage.

Second, iii)-v) indicate that seniority plays a role in the promotion process which is independent of the direct effect which seniority has on productivity in the skilled task. iii) states that for low levels of seniority no workers may be promoted even though at these levels of seniority

high ability workers are more productive at the skilled task.[8] iv) indicates that for every seniority level less than N for which a promotion occurs, the lowest ability worker promoted has a productivity in the skilled task which strictly exceeds that in the unskilled task, while for seniority level N the lowest ability worker promoted is equally productive across the two tasks. More generally, v) states that the minimum difference in productivity required to achieve a promotion is a decreasing function of the level of seniority. That is, consider two seniority levels greater than n^*, where n^* is the lowest seniority level of a worker in the skilled task. At the higher level of seniority there will be workers promoted whose extra productivity in the skilled task is strictly less than the extra productivity of workers at the lower level of seniority who are not promoted.

The intuition behind the result concerning wage rates and task assignments is similar to the intuition put forth in Waldman (1984a). In this model a worker's wage rate is determined by the wage offers of other firms rather than directly by the worker's productivity. Since other firms observe task assignments rather than ability levels, the result is that the actual wage paid is more closely related to the signal sent, i.e., the task assignment and date of promotion, than to the output the worker produces. A related point to note is that, for any worker of seniority n>0, the worker's wage equals the productivity of the lowest productivity worker associated with the same signal. This result is driven by our assumption that in the wage determination process the current employer gets to make a counter-offer after the other firms have already made their offers. As discussed in detail in Milgrom and Oster (1987) and Waldman (1990), in an environment characterized by counter-offers there is a winner's curse problem which prohibits potential

employers from bidding above the minimum productivity associated with a worker's signal. Hence, since in equilibrium the current employer just matches the wage offers of these potential employers, for each worker the actual wage paid is equal to this minimum level of productivity.

The intuition for the results concerning seniority is related. Because the wage offers of other firms depend on the signal sent, the current employer has an incentive to "distort" the signal in a manner which indicates the worker is of low ability. This explains why for every seniority level less than N for which a promotion occurs, the lowest ability worker promoted has a productivity in the skilled task which strictly exceeds that in the unskilled task. What further happens in equilibrium is as follows. The direct effect which seniority has on productivity in the skilled task provides the current employer with an incentive to only grant early promotions to high ability workers. This in turn causes two results. First, potential employers infer that a worker's ability is higher the earlier that the worker is promoted. Second, faced with such inferences, the current employer biases the promotion process against low seniority workers to an extent greater than that suggested by the direct effect which seniority has on productivity. In other words, there is an "additional" bias against promoting low seniority workers because the signalling effect of a promotion is stronger when the promotion is of a low seniority type.

As briefly discussed in the Introduction, this analysis differs substantially from the traditional analysis concerning how signalling works in the labor market (see, for example, Spence (1973) and Riley (1979)). In the traditional argument it is the worker who has private information about his own ability, and the worker has an incentive to distort behavior in a manner

which indicates that he is of high ability. The result is that, since there is typically a positive association between schooling and ability, the actual schooling levels chosen wind up being higher than those which are socially optimal. In contrast, here it is the firm which has private information, and the firm has an incentive to distort behavior in a manner which indicates that the worker is of low ability. In turn, since in this model the earlier the promotion the more positive the signal, the firm has an incentive to bias the promotion process against workers with low levels of seniority.

One important feature of this explanation for the role of seniority in promotion decisions is its consistency with another aspect of descriptive discussions of the promotion process. Milgrom and Oster (1987) argue that higher level tasks within a firm are typically associated with more visibility. That is, the higher the level of the task assignment, the less is information concerning a worker's ability private information to the current employer. Generalizing from Propositions 1 and 2 we now have the prediction that the higher the level of the task, the less important should seniority be in the promotion process. This is of interest because it is consistent with observations of the promotion process made by Doeringer and Piore (1971), Mincer (1974), and Edwards (1979). For example, Mincer states that "seniority is more important as a factor in promotion of blue collar than of white collar workers. It is least important in the professional, technical, sales and supervisory categories of jobs" (Mincer (1974), pp. 80-82).

III. THE RELATIONSHIP BETWEEN WAGES AND PRODUCTIVITY

Medoff and Abraham (1980) empirically investigate the relationship between wages and productivity in a data set where productivity is measured by performance evaluations of supervisors. They find two results which seem quite puzzling to those schooled in the human capital explanation for why wages grow over the career: (i) within a job category wages rise with seniority even though productivity does not; and (ii) within a job category wages rise with education even though productivity does not.[9] In this section I show that third party signalling provides a potential explanation for these findings. In a world characterized by third party signalling a worker's wage depends more directly on the signal that he is associated with rather than on his productivity. The result is that the average productivity of a group can change with seniority or schooling in a much different fashion than does the average wage paid to the group.

A) Wages, Productivity and Seniority

One potential explanation that Medoff and Abraham consider for their finding concerning seniority is that it is due to a negative correlation which they induce between seniority and productivity. Their argument for why they induce such a negative correlation is that, even if among the workforce as a whole there is a zero correlation between seniority and productivity, within a job category there will be a negative correlation since among higher seniority workers those more able will have been promoted to higher level jobs. After mentioning this idea as a potential explanation for their findings, they proceed to reject the explanation based on the further argument that if there is an induced negative correlation between productivity and

seniority, there should be an equally large induced negative correlation between wages and seniority. What I will show is that this latter argument is incorrect in an environment characterized by third party signalling.

To demonstrate this point I need to change the model of Section II only slightly. Let us assume there is an extra general human capital component to productivity. Specifically, if worker i with total labor market experience j is assigned to the skilled task it is now assumed that productivity equals $\alpha G(j)+f(j)+\theta_i$, while in the unskilled task productivity equals $\alpha G(j)+x+\delta\theta_i$, where $\alpha>0$, $G'>0$, $G''\leq0$. Also, assume that this is an overlapping generations model with cohorts of equal size, and as before let n^* denote the lowest level of seniority of a worker in the skilled task.

Proposition 3: In a cross section of workers in the unskilled task who have seniority n^* or more, the following hold.

i) The wage is a strictly increasing function of seniority.

ii) There exists a value $\bar{\alpha}$ such that if $\alpha<\bar{\alpha}$, then average productivity is a strictly decreasing function of seniority.

In Proposition 3 we find a result exactly consistent with the Medoff and Abraham finding, i.e., within a job category wages rise with seniority even when productivity does not. This result is driven by a combination of the induced negative correlation between productivity and seniority mentioned by Medoff and Abraham, and our assumption that in the wage determination process the current employer gets to make a counter-offer after the other firms have already made their offers. On the one hand, as long as only a moderate amount of general human capital is being accumulated, the fact that as seniority increases there is a shift of high ability workers from the

unskilled task to the skilled task causes a negative relationship between seniority and average productivity. On the other hand, consider the relationship between the unskilled wage and seniority. As discussed earlier, because of a winner's curse problem which prohibits potential employers from bidding above the minimum level of productivity associated with a worker's signal, in an environment characterized by counter-offers each worker's wage equals the productivity of the worst worker associated with the same signal. Hence, for each level of seniority the unskilled wage is determined by the productivity of a θ type worker, which given the inclusion of the extra general human capital term is increasing in seniority.[10]

One interesting aspect of the above explanation is that, as opposed to most other explanations for the Medoff and Abraham finding, this explanation is consistent with the human capital view for why wages grow over the career.[11] As indicated, the unskilled wage rises with seniority because the inclusion of the extra general human capital term causes the productivity of a θ type worker to rise with seniority. If this term were not present then the unskilled wage would be independent of seniority and the analysis would not provide an explanation for the Medoff and Abraham puzzle.

Another point worth noting is that the above explanation suggests the Medoff and Abraham result concerning seniority is more likely to be found in a cross sectional study as opposed to one which is longitudinal in nature.[12] There are two papers which perform tests similar to the original Medoff and Abraham study but which use longitudinal data sets. The two studies find different results and thus have different implications for the explanation being put forth here. Brown (1989) finds that wage growth reflects productivity growth, and thus his findings provide support for the explanation

put forth in this section. Medoff and Abraham (1981) perform both cross sectional and longitudinal tests on the same data set. They find results consistent with their earlier paper under both sets of tests. However, the discrepancy between wage growth and productivity growth is stronger in the cross sectional test, and thus their analysis suggests that the cross sectional findings may be due at least partly to this section's explanation.[13]

B) Wages, Productivity and Schooling

As indicated, the second puzzling result which Medoff and Abraham find is that within a job category wages rise with education even though productivity does not. What I show in this sub-section is that this result can be explained through an argument related to that put forth above.

The model of Section II now needs to be changed in the following fashion. There are two groups in the population. A proportion p of the workforce is in the no schooling group and individuals in this group have productivities across tasks exactly as in Section II. That is, if worker i with total labor market experience j of the no schooling group is assigned to the skilled task then his productivity equals $f(j)+\theta_i$, while in the unskilled task productivity equals $x+\delta\theta_i$. A proportion $(1-p)$ of the workforce is in the schooling group where the distribution of θ's for the schooling group is identical to that for the group with no schooling.[14] It is assumed that if worker i with total labor market experience j of the schooling group is assigned to the skilled task then productivity equals $f(j)+\theta_i+s$, while in the unskilled task it equals $x+\delta(\theta_i+s)$, where $s>0$ and $x>f(N)+(1-\delta)[E(\theta)+s]$. Below $\bar{\theta}^n$ will be the promotion standard for a worker of seniority n who is in the no schooling group, while $\bar{\theta}^n_s$ will be the promotion standard for a worker of seniority n who is in the

schooling group. For the latter I mean that a worker in the schooling group
is assigned to the skilled (unskilled) task if $\theta_i+s>(<)\bar{\theta}^n_s$. Also, let n^* now
denote the lowest level of seniority of a worker in the no schooling group
assigned to the skilled task.

<u>Proposition 4</u>:. If $\bar{\theta}^n<\bar{\theta}$ for $1\leq n<N$, then $\hat{\theta}^n<\bar{\theta}^n_s<\bar{\theta}^n$ $(\hat{\theta}^N=\bar{\theta}^N_s=\bar{\theta}^N)$. Also, the
following hold in a cross section of workers in the unskilled task who have
a fixed level of seniority $n\geq n^*$.

    i) The wage is a strictly increasing function of education.

   ii) The wage increases with education strictly faster than does
       average productivity.

  iii) There exist specifications for h(.) such that average productivity
       is a strictly decreasing function of education.

As was true for Proposition 3, Proposition 4 tells us that the wage need
not move in the same fashion as average productivity. In particular, consider
the wage and average productivity of workers in the unskilled task who have a
fixed level of seniority $n\geq n^*$. ii) indicates that the increase in the wage
associated with schooling is larger than the difference in average
productivity across the schooling and no schooling groups. Further, iii)
states that for some specifications of the distribution of innate ability in
the workforce, average productivity will actually be lower for those workers
with more education.[15]

This set of results is driven by two factors. First, as earlier the
wage paid to a worker is determined by the productivity of the lowest ability
worker associated with the same signal. Hence, since schooling increases the
productivity of the lowest ability worker, for the unskilled task the workers

with schooling receive more than those without. Second, one of the effects of schooling in this model is that it decreases the incentive for the firm to delay the promotion decision. The reason is that since the unskilled wage is higher for those with schooling, the firm has less of an incentive to distort the signal associated with that worker by not promoting him. One result is that holding productivity and seniority fixed, a worker with schooling is more likely to be assigned to the skilled rather than the unskilled task (this is captured by the result that if $\bar{\theta}^n < \bar{\theta}$ for $1 \le n < N$, then $\bar{\theta}^n_s < \bar{\theta}^n$ — see also Bernhardt (1990) for a related finding). More importantly, that the promotion standard does not rise with education yields that the difference in the wage for the two groups is larger than the difference in average productivities. Further, this is true to the extent that the average productivity for the schooling group in the unskilled task can in fact be less than that for the group with no schooling.

IV. CONCLUSION

A worker's current employer will typically possess information concerning that worker's productivity which is not directly available to other potential employers. A number of recent papers have considered this problem and argued that these other firms will utilize the actions of the current employer as signals of the worker's productivity, i.e., the market will be characterized by what I have referred to as third party signalling. In an earlier paper I considered a two period framework wherein other firms partially infer a worker's productivity by considering his task assignment, and showed that the third party signalling approach provides an explanation for why wage rates tend to be more closely associated with task assignments than with ability

levels. In this paper I consider what happens in such a setting when workers are modeled as being in the labor market more than two periods, and show that the third party signalling approach can explain a number of other labor market puzzles including: (i) why seniority is a factor in the promotion decision even after controlling for the effect seniority may have on productivity; (ii) why within a job category wages may rise with seniority even when productivity does not; and (iii) why within a job category wages may rise with education even when productivity does not.

APPENDIX

Proof of Proposition 1: Consider a worker of seniority N. Given the worker's ability is public information, other firms will be willing to bid for the worker the maximum output associated with that worker's ability level and total labor market experience, i.e., for a worker of ability θ_i the market will offer $\psi(\theta_i, N)$. Also, if one of these firms obtains the worker, then it will have an incentive to assign the worker to his output maximizing task. The current employer will have an incentive to make a counter-offer less than or equal to $\psi(\theta_i, N)$, and if the worker remains with the current employer then he has an incentive to assign the worker to the task which maximizes output. The result is $W(\theta_i, N) = \psi(\theta_i, N)$ for all θ_i and $\tilde{\theta}^N = \hat{\theta}^N$.

Given that nothing for labor market experience N depends on past actions, we can repeat the same arguments for N-1 and derive $W(\theta_i, N-1) = \psi(\theta_i, N-1)$ for all θ_i and $\tilde{\theta}^{N-1} = \hat{\theta}^{N-1}$. Further, repeating the argument for N-2, N-3, etc., yields that $W(\theta_i, n) = \psi(\theta_i, n)$ for all θ_i, n pairs where $n > 0$, and $\tilde{\theta}^n = \hat{\theta}^n$ for all $n > 0$.

Proof of Proposition 2: Due to space considerations, here I provide a proof that i) through v) constitute a sequential equilibrium to the model. In a proof available upon request I show that, given the two restrictions discussed at the beginning of Section II.B, this equilibrium constitutes the unique sequential equilibrium to the model. Consider a worker with total labor market experience N and suppose that i) through v) describe behavior for all $n \leq N-1$. Suppose $\theta_i < \tilde{\theta}^{N-1}$. The market will clearly offer $\psi(\underline{\theta}, N)$ since if it offered more the current employer would only match the offer if the worker's productivity was greater than or equal to the offer, and thus the worker would only switch firms if the wage exceeded productivity. The result

is that the current employer offers $\psi(\theta,N)$ and a skilled (unskilled) task assignment if $\theta_i > (<) \hat{\theta}^N$. Suppose $\bar{\theta}^{n'} < \theta_i < \bar{\theta}^{n'-1}$ and $1 \leq n' \leq N$. Using the same logic as above the market will offer $\psi(\bar{\theta}^{n'},N)$, and the current employer's response will be $\psi(\bar{\theta}^{n'},N)$ and a skilled task assignment. This yields $\bar{\theta}^N = \hat{\theta}^N$ and $f(N) + \bar{\theta}^N - (x + \delta\bar{\theta}^N) = 0$. Hence, given i) through v) describe behavior for all $n \leq N-1$, i) through v) also describe equilibrium behavior for $n = N$.

Now consider a worker with total labor market experience $N-1$ where the above describes behavior for $n = N$, and suppose i) through v) describe behavior for all $n \leq N-2$. Suppose $\theta_i < \bar{\theta}^{N-2}$. Similar to the above, the market will offer $\psi(\theta,N-1)$ since if it offered more the firm would match whenever the sum of the productivity minus the wage this period plus the discounted value of being the current employer next period was positive. In other words, whenever the worker switched firms the new employer would earn negative profits. The result is that the current employer offers $\psi(\theta,N-1)$ (note: there is no return here for a worker to switch employers given equal wage offers because of our assumption that a firm forgets the ability of a worker who leaves). If the firm promotes the worker in $N-1$ then, from the above, in the following period the wage bill increases by an amount $f(N) + \bar{\theta}^{N-1} - (x + \delta\theta)$. Hence, the worker is offered the skilled (unskilled) task if $f(N-1) + \theta_i - (x + \delta\theta_i) > (<) \beta[f(N) + \bar{\theta}^{N-1} - (x + \delta\theta)]$. Let $\tilde{\theta}^{N-1}$ be the value which when substituted for both θ_i and $\bar{\theta}^{N-1}$ equates the two sides of the above equation and suppose $\bar{\theta}^{N-2} > \tilde{\theta}^{N-1}$ if $\tilde{\theta}^{N-1} < \bar{\theta}$ and $\bar{\theta}^{N-2} = \bar{\theta}$ if $\tilde{\theta}^{N-1} \geq \bar{\theta}$ (note: if $1 - \delta \leq \beta$ then $\tilde{\theta}^{N-1} = \bar{\theta}$). Suppose $\bar{\theta}^{n'} < \theta_i < \bar{\theta}^{n'-1}$ and $1 \leq n' < N-1$. Using logic as above the market will offer $\psi(\bar{\theta}^{n'},N-1)$, and the current employer's response will be $\psi(\bar{\theta}^{n'},N-1)$ and a skilled task assignment (since it is an off the equilibrium path move we can assume that the future wage offers of other firms do not fall if the worker is demoted this period, and thus the

firm does not have an incentive to demote the worker). This yields $\tilde{\theta}^{N-1}=\min(\tilde{\theta}^{N-1},\bar{\theta})>\hat{\theta}^{N-1},\tilde{\theta}^{N}$ and $f(N-1)+\tilde{\theta}^{N-1}-(x+\delta\tilde{\theta}^{N-1})>f(N)+\tilde{\theta}^{N}-(x+\delta\tilde{\theta}^{N})=0$. Hence, given i) through v) describe behavior for all $n\leq N-2$, i) through v) describe equilibrium behavior for all $n\geq N-1$.

Repeating this argument for $N-2$ yields that $\tilde{\theta}^{N-2}$ is the solution to the equation $f(N-2)+\tilde{\theta}^{N-2}-(x+\delta\tilde{\theta}^{N-2})=\beta[f(N-1)+\tilde{\theta}^{N-2}-(x+\delta\underline{\theta})]+\beta^2[\tilde{\theta}^{N-2}-\tilde{\theta}^{N-1}]$ (where $\tilde{\theta}^{N-2}=\bar{\theta}$ if $1-\delta\leq\beta+\beta^2$). The assumption $\beta f(N)>f(N-1)$ and $f''<0$ yields $\beta f(N-1)-f(N-2)>\beta f(N)-f(N-1)$. Hence, if $1-\delta>\beta+\beta^2$ then $\tilde{\theta}^{N-2}>\tilde{\theta}^{N-1}$ and $\tilde{\theta}^{N-2}>\tilde{\theta}^{N-1}$ if $\tilde{\theta}^{N-1}<\bar{\theta}$, and i) through v) describe equilibrium behavior for all $n\geq N-2$. Repeating the argument for $N-3$, $N-4$, etc., yields that i) through v) describe equilibrium behavior for all n.

Proof of Proposition 3: Using the same arguments as in the proof of Proposition 2 yields that iii), iv) and v) of Proposition 2 hold where the values for $\tilde{\theta}^n$ are independent of α, while i) and ii) need to be amended as follows.

   i') $W(\theta_i,n)=\psi(\underline{\theta},n)+\alpha G(n)$ for all θ_i,n pairs, where $\theta_i<\tilde{\theta}^{n-1}$ and $n\geq1$

   ii') $W(\theta_i,n)=\psi(\tilde{\theta}^{n'},n)+\alpha G(n)$ for all θ_i,n,n' triplets, where $\tilde{\theta}^{n'}<\theta_i<\tilde{\theta}^{n'-1}$

      and $1\leq n'<n$

$G'>0$ immediately implies i) of Proposition 3. Let $Z(\theta)$ be the average value for $x+\delta\theta_i$ for all workers in a given cohort whose value for θ_i falls in the interval $[\underline{\theta},\bar{\theta}]$. It is clear that $Z'>0$. Consider seniority levels n and $n+1$ where $n\geq n^*$. The change in average productivity for workers in the unskilled task as we increase seniority from n to $n+1$ is given by (A1).

(A1) $$Z(\tilde{\theta}^{n+1})+\alpha G(n+1)-Z(\tilde{\theta}^n)-\alpha G(n)$$

Let $\alpha'(n)$ be the value for α which causes the expression in equation (A1) to equal zero. Given $\bar{\theta}^{n+1} < \bar{\theta}^n$, $Z' > 0$ and $G' > 0$, (A1) yields $\alpha'(n) > 0$ for all $n \geq n^*$. Let $\tilde{\alpha}$ be the minimum value for $\alpha'(n)$ over all values for $n \geq n^*$. (A1) now yields that for any $\alpha < \tilde{\alpha}$, average productivity strictly falls with seniority for all $n \geq n^*$. This proves ii).

<u>Proof of Proposition 4</u>: For the workers without schooling we have the identical model considered in Section II and thus Proposition 2 holds. For those with schooling we have the same model as in Section II except that $\theta_i + s$ now plays the role that θ_i played previously. Thus, i) through v) of Proposition 2 hold except that whenever there is a θ_i substitute $\theta_i + s$. This immediately yields $\hat{\theta}^N = \bar{\theta}^N_s = \bar{\theta}^N$. From the proof of Proposition 2 $\tilde{\theta}^{N-1} = \min(\bar{\tilde{\theta}}^{N-1}, \bar{\theta})$, where $\bar{\tilde{\theta}}^{N-1}$ is the solution to (A2) if $1-\delta > \beta$ and equals $\bar{\theta}$ otherwise.

(A2)
$$f(N-1) + \bar{\tilde{\theta}}^{N-1} - (x + \delta \bar{\tilde{\theta}}^{N-1}) = \beta[f(N) + \bar{\tilde{\theta}}^{N-1} - (x + \delta \underline{\theta})]$$

Similarly, $\tilde{\theta}^{N-1}_s = \min(\bar{\tilde{\theta}}^{N-1}_s, \bar{\theta})$, where $\bar{\tilde{\theta}}^{N-1}_s$ is the solution to (A3) if $1-\delta > \beta$ and equals $\bar{\theta}$ otherwise.

(A3)
$$f(N-1) + \bar{\tilde{\theta}}^{N-1}_s - (x + \delta \bar{\tilde{\theta}}^{N-1}_s) = \beta[f(N) + \bar{\tilde{\theta}}^{N-1}_s - (x + \delta(\underline{\theta} + s))]$$

(A2) and (A3) yield that if $\bar{\tilde{\theta}}^{N-1} < \bar{\theta}$, then $\hat{\theta}^{N-1} < \bar{\theta}^{N-1}_s < \bar{\theta}^{N-1}$. Repeating this argument for N-2, N-3, etc., yields that if $\tilde{\theta}^n < \bar{\theta}$ for $1 \leq n < N$, then $\hat{\theta}^n < \bar{\theta}^n_s < \bar{\theta}^n$.

Consider all workers in the unskilled task who have a fixed level of seniority $n \geq n^*$. From the above, the wage for those without schooling is given by $x + \delta \underline{\theta}$, while for those with schooling the wage is given by $x + \delta(\underline{\theta} + s)$. This proves i). Note that the difference in the wage between the schooling and no schooling groups equals δs.

Let $Z(\theta)$ be the average value for $x + \delta \theta_i$ for all non-schooled workers in a given cohort whose value for θ_i falls in the interval $[\underline{\theta}, \theta]$. Let $\theta^s = \theta + s$ and

let $h^S(\theta^S) = h(\theta)$ for all θ. $h^S(.)$ is the probability density function for the post schooling ability levels for those with schooling. Let $Z^S(\theta)$ be the average value for $x + \delta\theta^S$ for all schooled workers in a given cohort whose value for θ^S falls in the interval $[\underline{\theta}+s, \theta]$. It is clear that $Z^{S\prime} > 0$ and $Z^S(\theta+s) = Z(\theta)+\delta s$ for all θ. Given the above, the average productivity for the no schooling group equals $Z(\bar{\theta}^n)$, while for the schooling group average productivity equals $Z^S(\bar{\theta}^n_s)$. This means that if $\bar{\theta}^n_s = \bar{\theta}^n + s$, then the difference in average productivity between the schooling and no schooling groups equals δs. Hence, since $\bar{\theta}^n_s < \bar{\theta}^n$ and $Z^{S\prime} > 0$, the difference in average productivity across the two groups must be strictly less than δs. This proves ii).

Again, $Z^S(\bar{\theta}^n_s) = Z(\bar{\theta}^n_s - s) + \delta s$. Also, from the proof of Proposition 2 we see that the values for $\bar{\theta}^n$ and $\bar{\theta}^n_s$ do not depend on the specification of $h(.)$. We now have that the average productivity of the no schooling group will be higher than that for the schooling group for any specification for $h(.)$ such that $Z(\bar{\theta}^n) > Z(\bar{\theta}^n_s - s) + \delta s$, and such specifications necessarily exist given $\bar{\theta}^n_s < \bar{\theta}^n$. This proves iii).

FOOTNOTES

1. Other related papers include Greenwald (1986), Milgrom and Oster (1987), Borland and Prendergast (1988), Prendergast (1988), Novos (1988), Ricart i Costa (1988), Bernhardt (1990), Perri (1990), and Waldman (1990).

2. See Perri (1990) for an analysis which combines the traditional Spence type signalling approach with the third party signalling approach pursued here.

3. See Carmichael (1983) for an alternative theoretical explanation for why seniority is important in the promotion process.

4. If we were also to assume that all previous wages were also public information, then the equilibrium we consider would still be an equilibrium but it would no longer be unique.

5. The fact that in equilibrium there is no distinction between a worker's seniority and his total labor market experience is clearly one drawback of the model. I have done some preliminary analysis of a model similar to the one considered in this section, but which is characterized by turnover in equilibrium. My analysis suggests that it is possible to construct a model of this sort in which seniority and total labor market experience are distinct in equilibrium, seniority is a factor in the promotion process, and the rationale for the latter result is the same as for the current model.

6. In our analysis we assume that the wage offers of firms other than the current employer are the highest offers consistent with the offering firm, given its beliefs concerning the worker's possible values for θ, anticipating that its offer will earn non-negative expected profits. Even with this assumption, however, the public information case considered in Proposition 1 is characterized by multiple equilibria in that after each period a worker is indifferent concerning whether or not to change employers. In Proposition 1

we present properties which all of these multiple equilibria exhibit.

7. For earlier papers which look at the assignment of workers to tasks in the absence of third party signalling see Satinger (1975), Prescott and Visscher (1980), MacDonald (1982), Rosen (1982) and Waldman (1984b).

8. For example, if $\beta > 1-\delta$, then it can be shown that no promotions occur for workers of seniority less than N. It is also worth noting that the introduction of specific human capital would increase the lower bound on β consistent with no promotions occurring for workers of seniority less than N.

9. Medoff and Abraham also find that within a job category wages rise with total labor market experience even though productivity does not. Since in the equilibrium being considered there is no turnover and thus no relevant distinction between a worker's seniority and his total labor market experience, one can interpret what follows as being an explanation both for their result concerning seniority and for their result concerning total labor market experience. Note, in addition, preliminary analysis of a model characterized by turnover in equilibrium suggests it is possible to construct a model in which seniority and total labor market experience are distinct in equilibrium, and which exhibits the Medoff and Abraham findings concerning both variables.

10. One question which arises is what is the relationship between wages, average productivity and seniority for the skilled task. My analysis suggests that there are parameterizations of the model which will produce the Medoff and Abraham finding for the skilled task, but that the result is not as robust as is the finding for the unskilled task described in Proposition 3. It is worth noting, however, that if we allowed for more than two job categories (task assignments), then the factor which produces the Medoff and Abraham result for the unskilled task in Proposition 3 would be present for all but

the highest level task.

11. Other explanations for the Medoff and Abraham finding are put forth in Becker and Stigler (1974), Salop and Salop (1976), Freeman (1977), Lazear (1979), Harris and Holmstrom (1982), and Haltiwanger and Waldman (1986).

12. The current explanation relies on workers moving across tasks as seniority increases. It thus suggests that the result would not be found in a longitudinal analysis which followed a fixed set of workers who remained in the same task over an interval of time.

13. In the cross sectional test they find a significant positive relationship between salary and seniority and a significant negative relationship between performance and seniority. In the longitudinal test they find a significant positive relationship between salary and seniority, but the relationship between performance and seniority is less clear cut. As they state, "...for those persons not changing grade level, relative within-grade-level salary appears to rise substantially, while relative within-grade-level performance appears to remain roughly stable or to deteriorate" (Medoff and Abraham (1981), p. 204).

14. This is consistent with each worker not knowing his own value for θ, and schooling decisions then being determined by heterogeneity among workers concerning access to capital markets.

15. In this model the Medoff and Abraham finding concerning schooling does not hold for the skilled task. If we were to incorporate the idea that schooling increases the extent to which a worker's ability is public information, then the Medoff and Abraham result could hold even for the skilled task.

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