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EQUILIBRIUM DISMISSAL WITHOUT STIGMA†

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Abstract

Labor market models in which job separations are a component typically produce the implication that the reason for a job separation (*i.e.*, whether it is considered voluntary or not) is either immaterial in the determination of subsequent labor market experiences of the individual or has long-term stigmatizing repercussions. The model exposited in this paper is consistent with dismissals having real but transitory effects on the wage process of an individual. These effects constitute a punishment strategy pursued by the firm in order to induce optimal effort supplies on the part of its work force. Our empirical results indicate that the probability that a worker will face a punishment period due to an unlucky output draw is substantial. Moreover, it seems that the punishment period lasts for at least three years, a nonnegligible amount of time. Further work is needed to resolve the issue of whether or not the effects of dismissal are indeed transitory or are better regarded as permanent.

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1. INTRODUCTION

A number of authors have shown empirically that the effects of job separations on subsequent wage outcomes and/or the length of nonemployment following the separation depend on the stated reason for the termination of the employer-employee match.[1] For the most part, the effects have been measured only for the very short-run, so serious questions can be raised as to how important these differentials are when considering the entire labor market career of an individual.

Behavioral models in the labor literature which implicitly or explicitly address the link between wages and turnover yield very different implications concerning the nature of the relationship. For example, in the on-the-job search literature (e.g., Burdett (1978)), separations are always associated with wage gains. In the job matching literature (e.g., Jovanovic (1979), Miller (1984), and Flinn (1986)), the worker changing jobs (i.e., firms or occupations) experiences wage gains on average, but not with probability one. A further implication of most of the models in this literature is that the distinction between voluntary and involuntary separations is an irrelevant one. With common information regarding the profitability of the worker-firm match, and with costless renegotiation, only matches yielding rents less than the sum of the values of separation for workers and firms will be ended. Which party actually is recorded as initiating the separation is behaviorally irrelevant.

When the employment relationship is characterized by asymmetric information and possibly moral hazard, and where the imperfectly observed productive or preference characteristics of employees are not completely employer-specific, the potential signalling effect of separations (and particularly dismissals) on future labor market outcomes arises. The model contained in Greenwald (1986) is particularly clear in presenting the adverse

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[1]Empirical evidence concerning the effect of voluntary separation, involuntary separation, and nonseparation on wage growth is contained in papers by Bartel (1975), Bartel and Borjas (1981), and Mincer and Jovanovic (1981). Very roughly speaking, empirical evidence tends to indicate a difference in wage growth by reason for separation among individuals changing firm, with individuals reporting voluntary separations experiencing larger wage gains than individuals leaving involuntarily. The average wage growth experienced by stayers is less than that of voluntary movers and greater than that of involuntary movers.

effects of separations on future wages. In his model, employers are able to perfectly observe the abilities of their employees, while potential employers are not. Asymmetric information along with restrictions on the class of employment contracts which can be offered produces a lemons phenomenon in which the individuals changing employers have lower average ability than do stayers; an equilibrium exists in which job changers receive a wage less than the (uniform) wage of stayers. Gibbons and Katz (1989) empirically attempt to assess the relevance of the lemons phenomenon by examining the post-separation wages of individuals dismissed from their jobs and individuals separated for reasons assumed to be exogenous to their behavior, namely plant closings. They find some limited amount of support for the proposition that the post-separation wages of individuals exogenously separated are greater than those whose separation was presumedly a signal concerning their characteristics. Flinn (1990) contains a model of asymmetric information, employee heterogeneity, and moral hazard, in which quits and dismissals provide different signals concerning employee characteristics.[2]

While it seems reasonable to suppose that heterogeneity in the population of labor market participants is a necessary condition for stigma to arise, this is not actually the case. For example, consider the case where a firm has access to an indefinitely large number of potential employees, all of whom are *ex ante* identical and are homogeneous with respect to all permanent characteristics (i.e., preferences and abilities). Let the firm offer an employment contract which induces effort on the part of its employees, but let output be stochastic. If the firm observes an individual producing a level of output consistent with an inadequate supply of effort, it is optimal to dismiss him or her for an indefinitely long period of time. If all other firms are able to observe the employment record of the individual, it will be profit-maximizing for them not to hire previously dismissed individuals as well [or at least until the expiration of an equilibrium punishment period].

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[2] In addition, the potential signalling effects of separations on future labor market outcomes can be given empirical content in the heterogeneity-state dependence distinction of Heckman (1978). The relevant question might be whether the act of being dismissed "causes" an individual to be less productive in the future, presumably through the loss of specific human capital, or whether dismissal signals an individual's type which results in lower wage offers from firms in the future. Flinn and Heckman (1982) interpret the patterns of reemployment probabilities over and across spells of unemployment as being generated by signalling phenomena.

In this case, we would conventionally refer to a dismissal as being "stigmatizing," though in fact no information concerning the individual's type has been communicated. Rather, the observation that individuals are [temporarily] "stigmatized" following dismissal arises from the firm pursuing an optimal punishment strategy, which it must implement to retain credibility. This is a similiar setup to those employed in the trigger-price strategy models of Green and Porter (1984), Porter (1983b), and Radner (1984).[3]

The model developed here is also superficially similiar to the one proposed by Shapiro and Stiglitz (1984), which emphasizes the role of aggregate unemployment in inducing imperfectly observable effort on the part of employees. Our model also generates "unemployment," if we interpret unemployment as employment in a secondary sector. However, the relevant unemployment level for our case is that prevailing in a local labor market, and this level is endogenously determined by a primary sector monopsonist [or in competitive labor market equilibrium]. Furthermore, due to stochastic production and the [partial] observability of output, individuals in our model are actually dismissed, which is not the case in Shapiro and Stiglitz.[4]

While there are many ways in which an employee may be punished for failure to produce output, we will think of the punishment as taking the form of a relegation to a task characterized by a production technology in which moral hazard does not play a role. The metaphor we will use throughout is that of a "secondary sector" of the economy, though the overlap between the story told here and traditional models of dual labor markets is slight. Our model is related to those of of Albrecht and Vroman (1990), in which a "dual" labor market as produced as an equilibrium outcome when firms choose combinations of monitoring and wage contracts which are of equal value and in which dismissals occur due to heterogeneity in preferences among employees, and that of Strand (1991), who considers a non-equilibrium version of the

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[3]It is also interesting to note that in his empirical work on cartel behavior in the railroad industry, Porter (1983a) attempted to determine punishment periods (i.e., epochs of noncooperative behavior) and periods of cooperation from time series data on the shipping prices of railroad lines. Instead, the econometric model formulated below imposes the structure of the contract on the time series of wages and dismissals of individual in order to estimate underlying model parameters which characterize the contract and the environment.

[4]In their model, individuals only leave employers voluntarily for reasons not specified within the model.

model below in which fixed costs of employment have been added.[5] The econometric model developed below views wage observations as being generated by draws from primary and secondary sector wage distributions, which is similiar to the econometric model of Dickens and Lang (1985). The principal differences are that the model estimated below is dynamic and the regime probabilities are functions of behavioral parameters.

To briefly summarize the main points of the argument we will present, firms acting as primary sector monopsonists or as participants in a competitive labor market determine profit-maximizing contracts which induce effort on the part of homogeneous employees. The only partially observable indicator of effort is the output of individual employees. The contract specifies that employees are to be relegated to a secondary labor market for a fixed length of time whenever their individual output is observed to be deficient. Punishing employees is necessary for the firm to maintain the credibility of their contracts. Optimal punishments are always of finite length.

The plan of the paper is as follows. In Section 2 we describe a model in which profit-maximizing levels of wages and punishments are determined within a local labor market. We derive the equilibrium first under the assumption that the employer is a monopsonist and then under a competitive labor markets assumption. In both cases, we show that there exists unique equilibrium contracts which specify fixed punishment period lengths for employees found not to produce a unit of output in a given period. We use the behavioral model of Section 2 to specify an estimable model of the wage process in Section 3. Section 4 contains the results of our empirical analysis. We first present descriptive analyses of the effects of the dismissal and wage history on wages, which provides evidence on the negative effects of dismissals on wages. This section also contains estimates of a particular parameterization of the contractual model of the labor market. Section 5 contains a brief conclusion.

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[5]The work of Bulow and Summers (1986) in which jobs are characterized by differing monitoring and production technologies, also considers several issues related to those examined here.

2. A PARTIAL EQUILIBRIUM MODEL OF DISMISSALS

Labor market participants are assumed to be infinitely-lived,[6] and have linear current period return functions of the form

[1] $$U(w,e) = w - e,$$

where w is the wage received in the period and e is the effort expended on the job. There exist two markets in the economy, a primary and secondary market. In the secondary market, the wage is fixed at w_s and the amount of effort which must be expended every period is e_s, so that the welfare of an individual participating in this market at any point in time is $u_s = w_s - e_s$. Without loss of generality, in the sequel we will normalize the utility flow in the secondary sector to 0. In the primary market, there exists one or more firms which take the value of u_s as given in competing for employees, and which are (output) price-takers. The firm's production technology is stochastic. Each employee at the firm in a given period produces output according to:

[2] $$p(y=1|e\geq\xi) = \delta$$
$$p(y=1|e<\xi) = 0,$$

that is, in any period each employee can produce either zero or one unit of output. If the employee supplies the required amount of effort to produce a unit of output, ξ, the probability that a unit of output is actually produced is δ, which may be less than one. The second line of [2] states that an effort expenditure greater than or equal to ξ is a *necessary* condition for output to be produced. The technological parameter δ is assumed fixed and exogenous. A major difference between the primary and secondary sector is that effort *must* be expended in the secondary sector in the course of

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[6] It is straightforward to allow individuals in the labor market to be subject to a constant risk of death. In particular, we could allow individuals to die at a rate α and for replacement to occur at this rate so as to keep the population stable. As long as we restrict the death rate to equal the birth rate, none of the results below are altered. In particular, even though the stock of employees is continuously being replenished, it is never optimal for the firm to set the punishment period for nonperformance to infinity. To avoid notational clutter, we look at economy with only one birth cohort consisting of infinitely-lived individuals.

employment, while in the primary sector the supply of effort on the part of employees is volitional.

The other predetermined technological parameter describing the firm(s) in the primary sector is the rate at which employees can be monitored, π. The monitoring rate is assumed to be independent of the employment size of the firm, and is fixed over time. It is further assumed that which employees are monitored is independently determined in each period.

There are two components to the model, the optimal response of the employees to choices offered by the firms, and the firms' optimal contract choice given employee decision rules. We first discuss the employees' problem, and then the firm's behavior in a stationary environment.

Employee Behavior

In each period, individuals in the primary labor market are confronted with two options, whether to supply the amount of effort required to produce a unit of output, or whether to "shirk." Just as choosing the shirk option does not imply immediate dismissal (since not all employees are monitored each period, in general), supplying the effort required to produce a unit of output does not guarantee that the employee will not be fired during the period. Now under preference assumptions [1] and production technology [2], it is clear that the employee's choice set consists of two elements each period, $\mathcal{A} = \{e=0, e=\xi\}$. In this stationary model, since the returns associated with the two actions are time-invariant, an employee in the primary labor market will make the same decision each period. We specifiy these returns as follows.

Individuals beginning the period in the primary labor market are employed at a wage w. At the end of the period, an employee is monitored with probability π, and, if monitored, the firm determines whether the employee has or has not produced a unit of output. As stated above, given the employee supplied effort equal to ξ, output was produced with probability δ. It is impossible for the firm to determine whether a monitored employee has produced no output because effort was not supplied or effort was supplied but output was (randomly) not produced in the period. Thus, it must treat all individuals found not producing output in the period in an identical manner.

The punishment for not producing output is to be sent immediately to the secondary labor market. The length of time the individual is sent to this market is λ, $\lambda \in \mathbb{N}_+ \equiv \{1,2,\dots\}$. At the end of this punishment period, the individual is reinstated in the primary labor market; no previously dismissed individual is treated differently than one not previously dismissed.[7]

Under these assumptions, the expected value associated with shirking is

$$[3] \qquad V_s = w + \pi\beta^{\lambda+1}V_s + (1-\pi)\beta V_s ,$$

where β is the discount factor, which lies in the open unit interval. The second term on the right-hand side of [3] is the probability of being monitored multiplied by the value of being dismissed, which is simply the discounted value of reentering the primary sector after λ periods and choosing the shirk option again. The last term is the value of choosing the shirk option next period given continuation in the primary sector multiplied by the continuation probability.

The expected value of the working option is

$$[4] \qquad V_w = (w-\xi) + (1-\pi+\pi\delta)\beta V_w + \pi(1-\delta)\beta^{\lambda+1}V_w.$$

The net current period utility yield is $w-\xi$ in this case. The probability of supplying effort yet being dismissed is the probability of being monitored multiplied by the probability of not producing a unit of output given effort was supplied, $(1-\delta)$. The last term on the RHS of [4] gives the value of being dismissed multiplied by the probability of dismissal given that effort is supplied. The second term on the RHS is the value of continuing in the primary market next period (and working) times the probability of the event.

For an individual beginning the period in the primary labor market, the value of the choice is

$$[5] \qquad V_e = \max\ (V_s;V_w).$$

The decision rule of the agent then is

$$[6] \qquad \begin{array}{ll} \text{Shirk} & \Leftrightarrow \quad V_s > V_w \\ \text{Work} & \Leftrightarrow \quad V_s \leq V_w. \end{array}$$

The important point to note, before turning to the consideration of the

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[7]Since individuals are infinitely-lived, all labor market participants are dismissed at some point in time with probability one.

firm's problem, is that all individuals in the primary labor market make the same decision each period. For the firm to produce any output, a contract must be offered which induces *all* employees to work.

The Firm's Problem: Monopsony Case

There is assumed to be a single firm operating in the local labor market which is a price-taker in the output market; the output price, p, is also assumed to be time-invariant. If the profit-maximizing value of the contract is such that negative profits are generated, the firm cannot operate (i.e., offers a wage rate of 0).

There exists a large, but finite, number of individuals in the labor market.[8] Each labor market participant is either an employee of the firm at any moment in time or is working in the secondary labor market. We will assume that the firm has a sufficiently low rate of discount that approximating the firm's objective at any point in time by steady state values is justified. The firm's expected profits in the steady state are equal to its expected profits per worker, $p\delta$-w, times its number of employees in the steady state, which is (up to a factor of proportionality) the steady state proportion of the population employed by the firm [i.e., in the primary sector] times ($p\delta$-w). The steady state version of the firm's constrained optimization problem is

$$[7] \qquad V_f = \underset{(w,\lambda)}{\text{maximum}}\ \tilde{p}(\lambda)(p\delta - w) \qquad \text{s.t. } V_w(w,\lambda) \geq V_s(w,\lambda),$$

where $\tilde{p}(\lambda)$ is the steady state proportion of the labor force in the primary labor market. Strictly speaking, profits are proportional to the maximand in [7]; we have simply omitted the factor of proportionality.

We solve the firm's problem sequentially. Since the firm offers a contract which induces effort, employees are only dismissed each period due

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[8]The population of potential employees is finite so as to ensure that firm profits are bounded. [Finiteness is not required when the firm operates in a competitive labor market, since expect firm profits are zero.] The number of potential employees must be large enough to make our repeated replacement of (finite) sample moments with population moments valid, i.e., the law of large numbers must hold.

to bad luck in the production process. Since $\bar{p}$ is the steady state proportion of the labor market in the primary sector, it is defined as

$$[8] \qquad \bar{p} = (1-\pi+\pi\delta)\bar{p} + (1-\bar{p})/\lambda.$$

This relation follows from the fact that of the proportion $\bar{p}$ in the primary labor market last period, $\pi(1-\delta)$ were monitored and found not to have produced a unit of output, thus $(1-\pi+\pi\delta)$ is the continuation probability. By the same token, of the $(1-\bar{p})$ who were in the secondary labor market in the previous period, the proportion $1/\lambda$ are returning. Then the steady state employment proportion in the primary sector is

$$[9] \qquad \bar{p} = (1+\pi\lambda(1-\delta))^{-1}.$$

Note that $\partial\bar{p}/\partial\lambda < 0$ and $\partial^2\bar{p}/\partial\lambda^2 > 0$.

We now turn our attention to the no-shirking constraint. Since the firm will never wish to pay more than is required to induce effort, the optimal contract must belong to the set of those for which $V_w(w,\lambda) = V_s(w,\lambda)$. We can rewrite [3] as

$$[3'] \qquad V_s(w,\lambda) = \frac{w}{(1-\beta) + \pi(\beta-\beta^{\lambda+1})} .$$

In the same way, we can rewrite the value of supplying effort [4] as

$$[4'] \qquad V_w(w,\lambda) = \frac{w - \xi}{(1-\beta) + \pi(1-\delta)(\beta-\beta^{\lambda+1})} .$$

Then equating [3'] and [4'], we have

$$[10] \qquad w^*(\lambda) = \frac{\xi[(1-\beta) + \pi(\beta-\beta^{\lambda+1})]}{\pi\delta(\beta-\beta^{\lambda+1})} .$$

Through the use of [10], the firm's problem is reduced to the selection of the punishment period only, λ. To establish existence of a unique solution to the firm's problem, it is necessary to establish a few properties of w^*. First note that $\partial w^*/\partial\delta < 0$ and $\partial w^*/\partial\pi < 0$; that is, the incentive to supply effort is increasing in the likelihood that such effort will be productive and in the monitoring rate, therefore the no-shirking wage is a decreasing function of each.

Because we are working in discrete time, we must look at the properties of $w^*(\lambda)$ by successive differencing. We first establish that this function is strictly decreasing. Taking first differences, we have

$$[11] \qquad \Delta w^*(\lambda) = \frac{\xi[(1-\beta)+\pi(\beta-\beta^{\lambda+2})]}{\pi\delta(\beta-\beta^{\lambda+2})} - \frac{\xi[(1-\beta)+\pi(\beta-\beta^{\lambda+1})}{\pi\delta(\beta-\beta^{\lambda+1})}$$

$$= \xi(1-\beta)(\beta^{\lambda+2}-\beta^{\lambda+1}) \;/\; \pi\delta(\beta-\beta^{\lambda+1})(\beta-\beta^{\lambda+2})$$

$$< 0 \quad \text{for all } \beta \in (0,1) \text{ and } \lambda \in \mathbb{N}_+ ,$$

where $\Delta w^*(\lambda) \equiv w^*(\lambda+1)-w^*(\lambda)$. It is also straightforward to demonstrate that

$$[12] \qquad \text{sgn}[\Delta^2 w^*(\lambda)] = \text{sgn}[(\beta-1)^2\beta^{\lambda+1}(1+\beta^{\lambda})] > 0,$$

where $\Delta^2 w^*(\lambda) \equiv \Delta w^*(\lambda)-\Delta w^*(\lambda-1)$. Finally, we note that the limiting value of the no-shirking wage is

$$[13] \qquad \underline{w}^* \equiv \lim_{\lambda\to\infty} w^*(\lambda) = \frac{\xi(1-\beta) + \beta\pi}{\beta\pi\delta} .$$

Since the no-shirking wage function is a monotone decreasing function of the length of the punishment period, this limiting value is the lowest possible wage the firm could offer and produce output.

We can now substitute the no-shirking constraint into [7], and solve the firm's problem rewritten as

$$[7'] \qquad V_f = \max_{\lambda} \bar{p}(\lambda)(p\delta-w^*(\lambda)).$$

It is slightly awkward to characterize the solution to this problem because the w^* function is nondifferentiable in λ. We will begin by characterizing the solution to the firm's problem by assuming, for the moment, that it is differentiable, with a negative first derivative and positive second derivative, which is consistent with the qualitative properties of the discrete function. Subscripts on functions will denote partial derivatives in what follows. The (pseudo) first order condition for λ is given by:

[14] $$0 = \bar{p}_\lambda(p\delta - w^*) - \bar{p}w^*_\lambda .$$

Denote the candidate solution(s) to [14] by $\hat{\lambda}$. By the properties of the w^* and $\bar{p}$ functions, if the solution $\hat{\lambda}$ yields positive profits, then $p\delta - w^*(\hat{\lambda}) > 0$. We can show that there is only one solution to the firm's problem when the output price is sufficiently high to yield positive profits for some feasible λ (for the pseudo-optimization problem) as follows. The second order condition is

[15] $$\bar{p}_{\lambda\lambda}(p\delta - w^*) - 2\bar{p}_\lambda w^*_\lambda - \bar{p}w^*_{\lambda\lambda}.$$

Now the candidate solution is defined so that

[16] $$p\delta - w^*(\hat{\lambda}) = \bar{p}(\hat{\lambda})w^*_\lambda(\hat{\lambda})/\bar{p}_\lambda(\hat{\lambda}).$$

If we rewrite [15] after substituting the expression in [16], we have

[17] $$w^*_\lambda \left\{ \bar{p}_{\lambda\lambda}\bar{p}/\bar{p}_\lambda - 2\bar{p}_\lambda \right\} - \bar{p}w^*_{\lambda\lambda},$$

where the point of evaluation of the functions $(\hat{\lambda})$ has been dropped for notational simplicity. The term in braces in [17] is zero, so that the second partial at the candidate solution is $-\bar{p}(\hat{\lambda})w^*_{\lambda\lambda}(\hat{\lambda}) < 0$. Then there exists a unique solution to the firm's pseudo-maximization problem.

In deriving the solution to the actual optimization problem faced by the monopsonist, let $O(\lambda)$ denote the value of the firm's objective function when the punishment period is λ and the no-shirking wage is offered, *i.e.*,

[18] $$O(\lambda) = \bar{p}(\lambda)\{p\delta - w^*(\lambda)\}.$$

The choice set of the firm is $\lambda \in \mathbb{N}_+$. Then

[19] $$j^* = \arg\max \{O(j)\}_{j=1}^{\infty},$$

and $\lambda^* = j^*$ if $O(j^*) \geq 0$. If $O(j^*) < 0$, the firm will not produce any output; we will define the contract in this case to be $<w=0, \lambda=\infty>$.

The Firm's Problem: Competitive Case

We now analyze in the situation in which a number of firms operating in a local labor market compete for the services of laborers. We assume that all of the firms operating in the market produce output according to the same production technology and that they face the same output price which is fixed at p.

As we know, the active competition for laborers will typically transfer all the rents from employment matches to the workers. Formally, we look for a contract or contracts which solve the following constrained optimization problem

$$[20] \qquad V_c(w,\lambda) = \underset{\langle w,\lambda\rangle}{\text{maximum}} \; V_e(w,\lambda) \quad \text{s.t.} \quad V_w(w,\lambda) \geq V_s(w,\lambda), \quad V_f(w,\lambda) \geq 0 \; .$$

V_c then gives the value of the problem to the employee when the labor market is competitive. The first constraint in [20] is the no shirking constraint; the second is the constraint that each firm must expect to at least break even on each of its employees.

We will show that the solution to [20] implies that the second constraint holds as a binding equality. To do so, we begin by assuming that this is the case. For the firm to earn an expected profit of zero on each employee, it must be the case that

$$w = p\delta .$$

Under this equality, each firm will be indifferent as to the size of its work force.

Each employee's utility is a function of both w and the punishment period length. For any given value of the wage, the employee's expected utility is a decreasing function of the punishment period length. The highest expected utility level an agent could possibly receive would be the one associated with a contract of $\langle p\delta,1\rangle$, which gives the agent the highest wage rate possible for the firm to still break even and the greatest proportion of time in the primary sector of the economy. However, such a contract may not be feasible because it may not satisfy the no-shirking constraint, which is that $V_w(p\delta,1) \geq V_s(p\delta,1)$.

In the previous section, we showed that there existed a function $w^*(\lambda)$ which gave the minimum value of the contractual wage at which the employees would be indifferent between shirking and working for each value of the punishment period length. Moreover, we showed that this function is monotone decreasing in the punishment period length so that it can be inverted to yield a function $\lambda^*(w)$ which gives the minimum value of the punishment period length to induce indifference between working and shirking for a given value of the primary sector wage.[9] The equilibrium contract for the competitive labor market case is then $\langle p\delta, [\lambda^*(p\delta)]_+\rangle$, where $[x]_+$ denotes the smallest integer which is greater than x. If $\lambda^*(p\delta)$ is undefined, then there exists no competitive equilibrium contract for this market.

Letting $\lambda_c = [\lambda^*(p\delta)]_+$, it is obvious that the contract $\langle p\delta, \lambda_c\rangle$ is the solution to the problem posed in [20], if any solution exists. Employee welfare is increasing in w and decreasing in λ. Since the greatest wage at which the firm can break even is $p\delta$, no wage can be paid which is greater. For this wage, there exists no lower punishment period length than λ_c. Any lower contract wage will result in a punishment period length at least as great as λ_c, therefore producing strictly lower expected utility. Thus, the firm makes zero expected profits in equilibrium, and all of the rents of the match go to the employees.

It is also clear that, if there exists a contract which solves the program [20], the situation in which all firms in the local labor market offer the contract $\langle p\delta, \lambda_c\rangle$ constitutes a Nash equilibrium. No firm can offer a better contract from the point of view of employees and still earn nonnegative expected profits. Conversely, no firm can offer a contract which generates positive expected profits and is at least as highly valued by employees.

In concluding this section, let us compare the punishment contract equilibria in the monopsony and competitive labor market cases. First, assuming both contracts exist, the wage paid is unambiguously higher and the punishment period is no greater in the competitive case. Consequently, the steady state employment rate in the primary sector is at least as high in the competitive case as it is in the monopsony case.

Second, in reference to the econometric model developed in the following section, it is important to note that the mapping between the primitive parameters of the problem and the equilibrium contract values depend

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[9] In defining this function, we do not restrict it to take values only in the set $\mathbb{N}_+$. For values of w sufficiently low, no value of λ will be sufficient to induce effort. Such values cannot be an [productive] equilibrium for the model, and we treat $\lambda^*(\cdot)$ as being undefined in these cases.

critically on the nature of competition in the local labor market. In characterizing labor market dynamics, we will show that it is only necessary to estimate the contract values themselves along with one function of primitive parameters. In adopting this parameterization, we obviate the need for taking a position as to the nature of competition, at the cost of introducing the statistical problem of estimating a discrete parameter. We now turn to these issues.

3. ESTIMATION OF THE WAGE DISMISSAL PROCESS

In this section we consider the implications of the punishment strategy model for empirical processes of wages and dismissals. A maximum likelihood estimator will be proposed for all of the parameters which characterize wage dynamics, and we will also consider issues of identification of the primitive parameters which characterize the choice sets of employees and firms.

The stochastic process characterizing labor market outcomes is extremely simple. All individuals employed in the primary sector at time t have a probability of exiting into the secondary sector at time t+1 equal to the product of the monitoring rate in the primary sector and the probability of *not* producing a unit of output given the requisite effort expenditure, which we will denote by $1-\vartheta = \pi(1-\delta)$; the probability of remaining in the primary sector from t to t+1 is ϑ. For all individuals employed in the secondary sector at time t, the probability that they exit into the primary sector at time t+1 is equal to unity if they have been employed in the secondary sector for λ consecutive periods as of time t+1 and is otherwise equal to zero. Thus the stochastic process characterizing movements between the sectors is completely characterized by the two parameters ϑ and λ.

The stochastic process describing wages is also straightforward to describe. First note that in the model there exists no randomness in wages given the sector occupied; this is a characteristic which must be immediately altered if we are to use wage information from the sample (which must exhibit considerable amounts of variability conditional on sector[10]) in our estimators.

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[10] Even if we treat the sector occupied as unobservable in all periods, as we do in obtaining maximum likelihood estimates below, restricting the number of sectors to K implies at most K values of wages should be observed in each period. The fact that hourly wages in the sample take almost as many different values as there are sample members clearly indicates the need for

We take the easiest way out, and posit that conditional on sector, wage draws are i.i.d. normal within and across sample members with sector-specific means and a common variance.[11]

The dependent variables of the analysis are the observed wage sequences for the n sample members. Notably absent from the likelihood function are the observed dismissal sequences; however, these sequences are used for purposes of data description in the next section. We have chosen not to use dismissal information to estimate the structural model due to problems of specification and identification of a measurement error process for the dismissal information. To employ dismissal information, it is absolutely necessary to allow for some form of measurement error for the following reason. Under our modelling assumptions, dismissals only occur in the primary sector. When the punishment period length is λ, the probability that an individual experiences dismissals separated by fewer than λ periods is zero. Under the assumption that the observed dismissal process corresponds to the actual dismissal process, a number of the sample observations will be probability zero events under the model.[12] Therefore, to utilize information on dismissals in the likelihood function, for all possible values of λ a conditional probability distribution of observed dismissal sequences given actual probability sequences must be specified which has the property that no possible observed dismissal sequence has zero probability for all possible true dismissal sequences. Experimentation with a number of possible measurement error specifications for dismissals led us to the conclusion that difficulties in the precise estimation of the additional parameters associated with the measurement error process for the dismissal sequence more than offset the potential efficiency gains arising from the use of sample separation

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the addition of some continuously distributed measurement error in hourly wage rates.

[11]We restrict the variance terms across the two regimes to be equal as is standard in the estimation of normal mixture models to circumvent well-known unboundedness properties of the likelihood function [see, *e.g.*, Day (1969) and Quandt and Ramsey (1978)]. Since measurement error in wages has been appended to the behavioral model of sectoral occupancy, there seems to be no compelling reason to allow for sector-specific distributions of measurement error.

[12]Complicating matters further is the fact that certain sequences which are probability zero events for one value of λ are not probability zero events for other values of the punishment period length. Thus there is not the possiblity of excluding probability zero sample sequences when estimating λ since the set itself is a function of λ.

information in this case.

The likelihood function for the sample is simply a mixture of normal wage densities, where the probability distribution of the various regimes is a function of the two parameters λ and ϑ. Formally, we have

$$[21] \qquad g(\{w_t\}|\theta) = \sum_{\delta \in \mathscr{S}} f(\{w_t\}|\delta,\theta_1)\; p(\delta|\theta_2) \ ,$$

where $\mathscr{S}$ is the set of all sectoral employment sequences, f is the conditional multivariate normal density of wage sequences given the sectoral employment sequence δ, $\theta_1' = (\mu_p\ \mu_s\ \sigma)$, $p(\delta|\theta_2)$ is the marginal distribution of sectoral employment sequences, $\theta_2' = (\lambda\ \vartheta)$, and $\theta = \theta_1 \cup \theta_2$. The log likelihood for the sample then is $\mathscr{L} = \sum \ell n(g(\{w_t\}|\theta))$, where the summation takes place over all sample members.

Before more fully describing the distributions which define the log likelihood function, we will indicate the manner in which variation in the punishment period length affects the functional form of the log likelihood. Special attention must be paid to the parameter λ not only because it is one of the focal points in the contractual model with punishments, but also due to the fact that it is a discrete parameter assuming one of a countable infinity of values.

In the data set employed below, we have access to information from the first four years of labor market participation for each individual (T = 4). The data will not be informative in terms of distinguishing between values of λ in the set $\{4,5,\ldots\}$, so that effectively the set of possible values for the punishment length parameter must be restricted to the set $\{1,2,3\}$.[13] This limitation is especially apparent in our application due to the short sample period we have available to us.

The density of the sequence of the first four labor market wages given the sector of occupancy $\delta = (\delta_1\ \delta_2\ \delta_3\ \delta_4)'$ is

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[13] While it is possible to circumvent this particular problem by parameterizing the likelihood function in terms of the primitive parameters of the model, such as π and δ, this approach introduces its own problems of parameter identification and computation. In addition, such a parameterization necessitates the choice of a monopsonistic or competitive view of the local labor market, as was pointed out in the previous section. For these reasons, we have chosen to estimate this parameterization of the behavioral model.

$$[22] \qquad f(\{w_t\}|\Delta,\theta_1) = \sigma^{-4} \prod_{t=1}^{4} \phi((w_t-\mu_{\Delta_t})/\sigma) \ ,$$

where ϕ denotes the probability density function of a standard normal random variable.

In order to derive the probability distribution of Δ, some assumptions are required regarding the manner in which individuals are allocated to sectors upon entry into the labor market. Two allocation mechanisms immediately suggest themselves. The first candidate would have all labor market entrants immediately taking positions in the primary sector. This story is reasonable both because employees strictly prefer being in the primary to the secondary sector and since primary sector firms are willing to employee an unlimited number of employees at the equilibrium contract $\langle w,\lambda\rangle$.

This story, while appealling behaviorally, has some troublesome implications for the empirical process of sectoral occupancy. In this model, the period in which agents are most likely to be in the primary sector is their first in the labor market, which we know is typically associated with the lowest wage rate over the early years of labor market participation. Such an allocation mechanism is virtually certain to produce the implication that primary sector wages are lower than secondary sectory wages. While such a result is not strictly at odds with the behavioral model developed here,[14] we have chosen a second specification for the initial allocation process which doesn't seem to preordain such a result.

This second candidate has the liability of not being strictly consistent with the model as specified above, but has the major advantage of maintaining the proportion of labor market participants in the primary sector at a constant value over the life cycle. To derive the steady state proportion of individuals in the primary sector, we first assume that for a given punishment period length of λ, the length of time agents currently in the secondary sector have been in that sector has a [discrete] uniform distribution, so that the probability that an individual has been in that sector for ℓ periods equal to $1/\lambda$ for $\ell \in \{1,\ldots,\lambda\}$. For a punishment period length of λ, let the

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[14] Recall that we have only derived the result that per period utility is higher in the primary sector than in the secondary sector; there is no necessary ordering of the sectoral wage rates.

proportion of employees of labor market age t in the primary sector be denoted $\omega_\lambda(t)$. Then

$$\omega_\lambda(t+1) = \vartheta\omega_\lambda(t) + \lambda^{-1}(1-\omega_\lambda(t)) \; .$$

The steady state proportion of agents in the primary sector is given by

$$\omega_\lambda = (1+\lambda(1-\vartheta))^{-1}.$$

For each value of λ, we assign the proportion ω_λ to the primary sector in the first period. Of the remaining proportion of $1-\omega_\lambda$ agents waiting to enter the primary from the secondary sector, a proportion $1/\lambda$ are allowed to enter in periods 2 through $\lambda+1$. In this way, the proportion of agents in the primary secondary is kept at ω_λ over the cohort's life cycle.

Table 1 contains the probabilities of sectoral occupancy sequences for different values of λ under the stationarity assumption. While there are 16 possible sectoral occupancy sequences, a large number have probability zero for values of λ = 1, 2, or 3 or more under the model. For example, the probability of the sequence *PSPP* is $\omega_1(1-\vartheta)\vartheta$ when $\lambda = 1$ [that is, it is the product of the probability of entry in the first period, the probability of not producing a unit of output and being monitored during period 1, the probability [which is unity] of being punished for one period given the individual was monitored and didn't produce a unit of output during the previous period, and the probability of not being found not to have produced a unit of output during period 3]. For any punishment period length greater than 2, the probability of this sequence is zero, since it includes a stay of only one period in the secondary sector. It is important to note that while there are a large number of non-zero probabilities to be estimated for each of the possible values of λ, in all cases these probabilities are *only* a function of one parameter, ϑ.

There is a substantial literature on the estimation of mixtures of normal distributions to which we will refer the reader for a more detailed discussion of some of the statistical issues involved (*e.g.*, Cohen (1967), Day (1969), Quandt and Ramsey (1978)). We note that the problem of unboundedness of the log likelihood function when there is no restriction on the variances across regimes [sectors, in our application] has been already addressed by our assumption of constant measurement error variances in wages across sectors. Under this assumption and normality, the only differences in wage

TABLE 1

Probability Distribution of Sectoral Occupancy Sequences as a Function of Punishment Period Length (λ)

(*P* denotes primary sector and *S* denotes secondary sector)

Sector Occupied				*Punishment Period Length*		
1	*2*	*3*	*4*	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$
P	*P*	*P*	*P*	$\omega_1\vartheta^3$	$\omega_2\vartheta^3$	$\omega_3\vartheta^3$
S	*P*	*P*	*P*	$(1-\omega_1)\vartheta^2$	$(1-\omega_2)\vartheta^2/2$	$(1-\omega_3)\vartheta^2/3$
P	*S*	*P*	*P*	$\omega_1(1-\vartheta)\vartheta$	0	0
P	*P*	*S*	*P*	$\omega_1\vartheta(1-\vartheta)$	0	0
P	*P*	*P*	*S*	$\omega_1\vartheta^2(1-\vartheta)$	$\omega_2\vartheta^2(1-\vartheta)$	$\omega_3\vartheta^2(1-\vartheta)$
S	*S*	*P*	*P*	0	$(1-\omega_2)\vartheta/2$	$(1-\omega_3)\vartheta/3$
S	*P*	*S*	*P*	$(1-\omega_1)(1-\vartheta)$	0	0
S	*P*	*P*	*S*	$(1-\omega_1)\vartheta(1-\vartheta)$	$(1-\omega_2)\vartheta(1-\vartheta)/2$	$(1-\omega_3)\vartheta(1-\vartheta)/3$
P	*P*	*S*	*S*	0	$\omega_2\vartheta(1-\vartheta)$	$\omega_3\vartheta(1-\vartheta)$
P	*S*	*P*	*S*	$\omega_1(1-\vartheta)^2$	0	0
P	*S*	*S*	*P*	0	$\omega_2(1-\vartheta)$	0
P	*S*	*S*	*S*	0	0	$\omega_3(1-\vartheta)$
S	*P*	*S*	*S*	0	$(1-\omega_2)(1-\vartheta)/2$	$(1-\omega_3)(1-\vartheta)/3$
S	*S*	*P*	*S*	0	$(1-\omega_2)(1-\vartheta)/2$	$(1-\omega_3)(1-\vartheta)/3$
S	*S*	*S*	*P*	0	0	$(1-\omega_3)/3$
S	*S*	*S*	*S*	0	0	0

where $\omega_\lambda \equiv (1+\lambda(1-\vartheta))^{-1}$ *for* $\lambda = 1,2,3$.

distributions across sectors are the means. To identify the parameters θ_2, we require the following identification condition.

Identification Assumption: The primary sector wage (μ_p) is not equal to the secondary sector wage (μ_s).

If this assumption fails, then the wage distributions in the two sectors are identical, and obviously the parameters λ and ϑ will not be estimable from wage data alone. This identification condition is not vacuous due to the fact that the model does not produce this inequality condition in the determination of labor market equilibrium.

Under the identification restriction, the parameters θ are estimable. Because one of the parameters is discrete, and due to the well-known numerical problems associated with the estimation of mixtures models, we adopted the following strategy in deriving maximum likelihood estimates and their approximate asymptotic distribution. Using only the distribution of wages in the first period of labor market participation, we used the method of moments to obtain $\sqrt{n}$-consistent estimates of all of the parameters in the model for each value of λ. Under our stationarity assumptions, the marginal distribution of wages in any period is given by $f(w|\theta) = \omega_\lambda(\vartheta)f(w|\mu_p,\sigma^2) + (1-\omega_\lambda(\vartheta))f(w|\mu_s,\sigma^2)$. Using the first period wage distribution and method of moments estimators from Cohen (1967), we obtained $\sqrt{n}$-consistent estimates of μ_p, μ_s, σ, and $\omega_\lambda(\vartheta)$. For each value of λ, our consistent estimate of the $\omega_\lambda(\vartheta)$ yielded a $\sqrt{n}$-consistent estimate of ϑ.

Starting from the $\sqrt{n}$-consistent estimates for each value of λ, we take one Newton step to obtain asymptotically-efficient estimates of all model parameters for each value of λ.[15] Let the value of the log likelihood obtained after taking a Newton step from initial consistent estimates for a given value of λ be given by $\mathcal{L}(\lambda)$. Our maximum likelihood estimate of λ then is j, where $\mathcal{L}(j) > \mathcal{L}(k)$ for all $k \neq j$. We have not computed an asymptotic sampling distribution for the discrete parameter estimator $\hat{\lambda}$, and we present estimates of asymptotic standard errors for the parameters μ_p, μ_s, σ, and ϑ

[15] This procedure was suggested by Lehmann (1983, p.442). In his comment on Quandt and Ramsey (1978), Kiefer (1978) suggested using the Quandt-Ramsey moment generating function estimator as the starting point for the Newton step.

which do not take into account the sampling error in $\hat{\lambda}$.[16]

In concluding this section, let us add a few comments concerning the identification of the primitive parameters of the model from the parameterization implemented here. Under the monopsony assumption, the equilibrium wage in the primary sector is $\mu_p(\lambda)$, which is a function of the parameters p, ξ (the required effort level in the primary sector), β, π, and δ [under the assumption that $u_s = 0$]. The parameter $\vartheta = 1 - \pi(1-\delta)$. Our parameterization yields consistent estimates of two parameters which our functions of five primitive parameters, clearly indicating the need for further normalizations if consistent estimates of a subset of primitive parameters to be obtained. Perhaps it is most natural to consider restricting p, β and ξ to be equal to predetermined values. In this case, one can show that it is possible to obtain consistent estimates of the primitive parameters π and δ from the estimates obtained from our parameterization of the wage process.

When the labor market is competitive, the primary sector wage is equal to $p\delta$ and the dismissal rate is again a simple function of π and δ. If we normalized output price at some predetermined value, it is possibly to uniquely identify π and δ individually. Using a consistent estimate of λ in conjunction with this estimates, it should be possible to determine the value of either β or ξ.

4. EMPIRICAL RESULTS

The sample used in the empirical work was drawn from the National Longitudinal Study - Youth Cohort [NLSYC], which is [for the most part] a nationally-representative sample of approximately 12000 individuals who were 14-21 years of age in 1979. These individuals have been reinterveiwed on an annual basis during the 1980's; currently, nine waves of information are available for the years 1979-1987.

In defining our subsample several stringent criteria were imposed. To avoid problems of intermittent labor market participant, only males were included. Initial conditions problems were largely circumvented by requiring

[16] Which is to say, we present the estimates of asymptotic standard errors from the conditional estimation problem, where λ is fixed at the value $\hat{\lambda}$.

each sample member to be engaged in full-time schooling and be out of the labor market in one of the years 1979-1983, and then to be employed at the time of the next four consecutive interviews. The employment condition at the time of the interviews was imposed because no explanation of unemployment is included in the model.[17] Finally, only cases with complete information on wages and reasons for job separations [along with a few other demographic characteristics not included in the present study] were eligible for inclusion in the sample. The sample with which we work includes 198 individuals.

Our assumptions concerning the timing of actions in the labor market is depicted in Figure 1. At sampling point 0, the individual is enrolled in full-time schooling. At sampling points one through four, the individual is employed and has a reported wage w_t, t=1,2,3,4. We assume throughout that the natural time unit of the model corresponds to the sampling interval of one year. It follows that there are at most three possible times of output evaluation. Whether or not there is an output evaluation depends on the sector in which the agent is employed, and given primary sector membership, whether monitoring occurs.

Our behavioral model provides no rationale for intrasectoral job changes, but we did not further restrict our sample by limiting job changes to be no more than one per sampling period. In constructing the dismissal sequence used in the descriptive analysis below, we examined the reported reason for all job changes occurring over each sample period. If an agent reported that any job held during the period between the interviews ended due to a "dismissal" or a "layoff," the individual was considered to have been dismissed from the primary sector during that period.[18] The admitted arbitrariness of such a definition is one of the reasons it was not used in the estimation of the contract model, though this sequence does appear to negatively impact the annual wage sequence as we expect.

The sample is described in Table 2, where the average and the standard deviations of hourly wages are given by year for each of the possible eight

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[17] To the extent that unemployment experiences are significant components of the punishment strategies utilized by firms, not incorporating unemployment spells into the behavioral and econometric models may be considered an important source of misspecification.

[18] In point of fact, the survey records information on up to five job spells for sample period, though few respondents seem to hold more than five jobs in any one year period.

FIGURE 1

Timing Conventions in the the Model

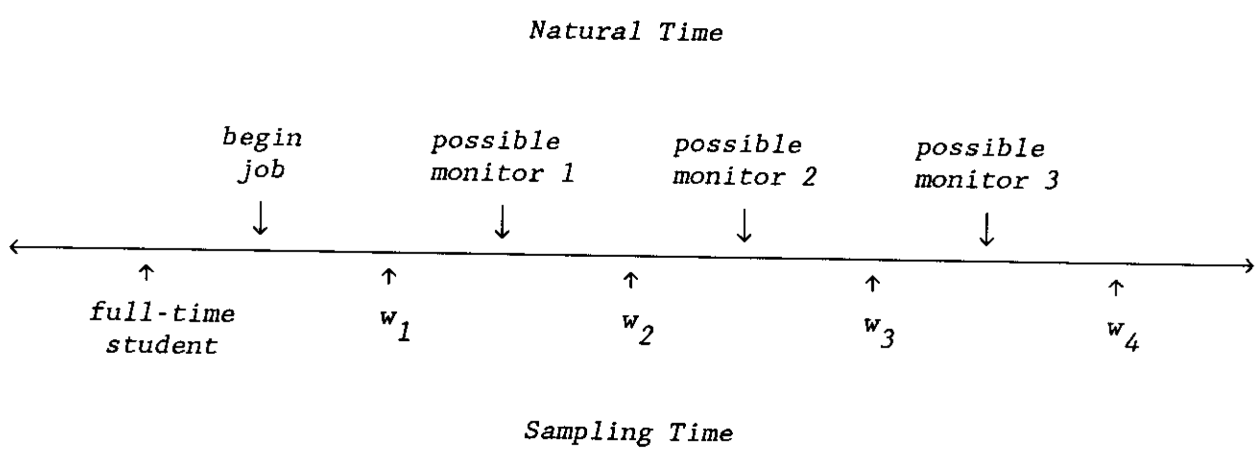

TABLE 2

Means and Standard Deviations of Wage Sequences Conditional on Dismissal Sequence

Dismissal Sequence			*Hourly Wage Rate*				
d_1	d_2	d_3	w_1	w_2	w_3	w_4	*Sample Proportion*
	ALL						
0	0	0	4.97 (2.27)	5.69 (2.57)	6.32 (3.05)	7.06 (3.83)	.778
1	0	0	4.49 (1.81)	3.98 (.89)	4.77 (1.77)	5.44 (1.87)	.086
0	1	0	4.87 (1.96)	4.13 (1.70)	4.06 (2.44)	3.71 (1.69)	.040
0	0	1	3.20 (.36)	4.56 (3.26)	4.15 (1.44)	5.04 (2.19)	.035
1	1	0	6.09 (3.93)	6.60 (1.68)	4.65 (1.36)	5.64 (1.96)	.035
1	0	1	4.18 (1.50)	4.19 (1.50)	4.39 (1.75)	5.40 (.52)	.015
0	1	1	12.19 (11.05)	5.87 (1.25)	10.13 (9.81)	3.93 (1.46)	.010
1	1	1	-	-	-	-	0

dismissal sequences. All wages have been expressed in terms of 1980 dollars. In terms of the occurence of dismissals, more than three-fourths of this sample reports no dismissal or layoff over their four years in the labor market, though one must keep in mind that the restriction that all sample members be employed at the time of each interview probably leads to downward-biased estimates of dismissal rates in the population. Approximately 16 percent of the sample reported one dismissal over the entire period, 6 percent reported two, and no sample member reported three. Of those individuals reporting one or two sampling periods with dismissals, dismissal experiences are largely concentrated in the first two years of labor market participation. Such a result is consistent with either dismissal rates being nonstationary or with disproportionate occupancy in the primary sector at the initiation of the labor market career.

Only dismissal sequences with zero or at most one reported dismissal have enough observations to make interpretation of the associated wage sequences worthwhile. For the group which experiences no dismissals over the sample period, average wages increase in very regualar increments; in period four, average hourly wages are 40 percent greater than their first period level. Conversely, the groups which experience one dismissal exhibit at least one period of decline in average wages over the four year interval. The largest of these groups, the one in which the dismissal occurs between the first and second wage observation, exhibits a noticeable drop in average wages from the first to the second period. After the second period, wages increase in a regular fashion, though in the fourth period the average wage is still less than the average wage in the second period for those exhibiting no dismissals. The group defined by having one dismissal between the second and third wage observations has a steadily decreasing pattern of average wages, and there is not a large drop in average wages between the second and third sampling period. The group with their one dismissal occurring between the third and the fourth sampling period actually experience an increase in average wages at this time. The extremely small numbers of individuals in these last two groups make any more detailed examinations of patterns precarious.

In Table 3 we examine the effect of the dismissal history on current wages both conditionally and unconditionally on the wage history of the individual. In this analysis and the one which follows, the natural logarithm of wages will be used instead of the level. We have estimated the regression function using ordinary least squares, and have reported both the standard OLS

TABLE 3

OLS Regressions of Ln Wages on the Dismissal and Ln Wage History

(Homoskedastic Standard Errors in Parentheses)
[Eicker-White Heteroskedasticity-Consistent Standard Errors in Brackets]

	Dependent Variable					
Coefficient	$\ell n(w_2)$		$\ell n(w_3)$		$\ell n(w_4)$	
Constant	1.625	.666	1.714	.185	1.822	.303
d_1	-.132 (.086) [.068]	-.123 (.066) [.071]	-.170 (.099) [.082]	-.063 (.061) [.070]	-.058 (.098) [.078]	.072 (.059) [.058]
d_2			-.192 (.121) [.144]	-.271 (.074) [.115]	-.340 (.121) [.103]	-.283 (.075) [.079]
d_3					-.206 (.138) [.098]	-.064 (.083) [.097]
$\ell n(w_1)$		.635 (.054) [.069]		.306 (.063) [.096]		.038 (.065) [.064]
$\ell n(w_2)$				.659 (.064) [.084]		.422 (.077) [.083]
$\ell n(w_3)$						.449 (.070) [.077]
R^2	.012	.419	.036	.646	.062	.671

standard errors under the homoskedasticity assumption on the disturbances and the Eicker-White heteroskedasticity-consistent standard errors which are asymptotically valid under any pattern of heteroskedasticity in the population.

The regressions of the second period log wage rate on the binary variable indicating dismissal between periods one and two reveal (marginally) significant negative effects of this experience whether or not we condition on the period one log wage rate. The absolute size of the coefficient is also unaffected by the inclusion of the wage history.

Regressions of third period log wage rates on the dismissal history reveal similiar patterns when we do not condition on the wage history. The effects of a dismissal on the third period log wage are roughly independent of the timing of the dismissal. The size of the dismissal effects is a bit larger than was the case for the regression reported in column 1 of the table. When we condition on the wage history as well (column 4), dismissals between the first and second wage observations no longer have statistically signficant effects on third period log wages, no doubt due to the transmission of the consequence of dismissal to second period log wages. However, dismissal between periods 2 and 3 substantially reduces the log wage rate in the third period conditional on the wage history.

Regressions of log wages in the fourth period yield slightly different patterns of the coefficients. When the regression includes only the dismissal sequence, second period and third period dismissals are found to have large and statistically significant effects on wages. Experiencing a dismissal in the first period is associated with lower fourth period wages, though the coefficient is insignificantly different from zero. The effect of a second period dismissal on fourth period wages is especially notable both for its absolute size and signficance level. When we condition on the wage history, only the second period dismissal indicator has a coefficient statistically significant from zero. For whatever reason, adjustments in third period wages apparently are not sufficient to capture the effects of prior dismissals in this regression function.

Having some understanding of the wage and [measured] dismissal patterns observed in these data, we are ready to move on to the implementation of the econometric model derived in Section 3. As was the case for the regressions performed, we use log wage information in estimating the model.[19] In order to get rid of the confounding influences of secular increases in wages due to labor market experience, we have normalized log wages so that the means of the distributions are constant through periods 1 through 4. This normalization is not inconsequential for the model estimates.

Table 4 presents the maximum likelihood estimates of the mixtures of normal distributions model conditional on punishment period lengths of 1, 2, and 3. One important point to note from the outset is that we have *arbitrarily* labeled the distribution with the high wage as being that of the primary sector. As we have pointed out numerous times previously, the model a finding of higher wages in the secondary sector is competely consistent with the model.[20]

The model estimates indicate that the primary sector log wage is about 50 percent larger than the secondary sector log wage for all three values of the punishment length parameter considered. The probability of continuation in the primary sector under the no-shirking contract varies from .758 (λ=2) to .804 (λ=1).

The values of the log likelihoods indicate that out of the restricted set of λ available to us, the choice of $\lambda = 3$ is associated with by far the largest value of the log likelihood. Thus our maximum likelihood estimates for the model as a whole consist of this choice for the punishment length parameter and the parameter estimates reported in column 3 of the table.

The model estimates indicate that there is considerable variation in production given fulfillment of the minimum effort requirement. For a given value of ϑ, the largest value δ can assume corresponds to a value of the monitoring rate of 1, in which case ϑ and δ are equal; therefore, the estimates indicate the production occurs *no more than* 78 percent of the time given effort. Apparently, dismissal is not a rare phenomenon in the labor market, and the impact of dismissals lasts for a relatively large number of periods. Given the limited sample observation period, we are unfortunately

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[19] Simply replace w with $\ell n(w)$ in the specification of individual preferences [1] and continue the analysis from that point in an exactly parallel manner to that reported in the text.

[20] While the use of sample separation information [*i.e.*, sample information on dismissals] may aid in resolving the ambiguity, this will only strictly be the case under several restrictions on the nature of the measurement error process in the dismissal sequence.

TABLE 4

Maximum Likelihood Estimates of Mixture of Normals Model for Alternative Punishment Period Lengths

	Punishment Period Length		
Parameter	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$
μ_p	2.128 (.010)	2.117 (.011)	2.109 (.011)
μ_s	1.387 (.026)	1.367 (.015)	1.370 (.013)
σ	.274 (.004)	.274 (.004)	.278 (.004)
ϑ	.804 (.058)	.758 (.047)	.778 (.053)
$\mathcal{L}$	-1772.923	-1074.369	-894.658

unable to say when, if ever, the punishment period concludes.

5. CONCLUSION

Most labor market models in which previous separations (and sometimes the reasons for them) signal information concerning the distribution of rents facing a potential employer yield the implication that separations result in lower future welfare for employees [*e.g.* Flinn (1990)]. In the model developed here, homogeneous employees working in the primary sector take the same action each period, but due to a stochastic production technology may be observed not to produce any output in a given period. As in the trigger price strategy literature concerning equilibrium cartel behavior in stochastic environments [see the paper by Green and Porter (1984) for example], the firm must punish nonproductive employees to maintain credibility. In the situation in which the firm earns positive expected profits on each employee, as in the monopsonistic case we considered, punishments have an opportunity cost for the firm. We show that when the punishment period is fixed, there exists a unique optimal fixed-wage, fixed-punishment period contract which maximizes the steady-state firm profit function. In this contract, the punishment period is finite and strictly positive. We also established the existence of such contracts when the labor market is competitive and a Nash equilibrium obtains. The alternative characterizations of the market imply different mappings from primitive parameters to the contract, but similiar stochastic processes describing labor market dynamics. We use the implications of the model to specify an econometric model of the joint wage-dismissal process. Using data consisting of four years of wage observations and dismissals reported by a sample of young male workers newly entering the labor market, we have obtained some preliminary estimates of the model under homogeneity assumptions on the workers and without using potential sample separation information gathered from self-reports on reason for job separations. Our estimates suggest substantial differences in the wages paid in the two sectors of the market, though one limitation of our econometric model is its inability to determine which wages correspond to which sector. Though continuation rates in the primary sector are high, individuals in the primary sector face a nonnegligible risk of being unlucky in production each period. It appears that consignment to the secondary sector lasts for a period of at least three years given the detection of no output in a period. Such results call into question the optimality of punishment strategies such as those considered here.[21]

We plan to extend the econometric work reported here in several dimensions. Most importantly, we will attempt to utilize self-reported dismissal information along with an appropriate model of reporting error to increase efficiency of parameter estimates and to aid in identification of the wage distributions with particular sectors. The results reported here clearly indicate the need for a larger sample, both in terms of the number of individuals and the length of the sampling period. Moreover, under the stationary restrictions on the stochastic process describing sectoral occupancy, initial conditions problems are relatively easy to deal with. It may make a great deal of sense to apply this model to individuals in the middle of the labor market career, rather than young or old workers.

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[21] Regarding such issues, see Abreu *et al* (1986).

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