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Valuable Jobs and Uncertainty

Joseph A. Ritter
Lowell J. Taylor

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FEDERAL RESERVE BANK OF ST. LOUIS
Research Division
411 Locust Street
St. Louis, MO 63102

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Abstract

Little attention has been given to the link between variation in a firm's circumstances and the resolution of agency problems that pervade the relationship between a firm and its employees. We construct stochastic versions of standard efficiency-wage and performance-bonding models and find that this connection has important and apparently inescapable consequences: (1) Compensation levels depend on characteristics of the firm. (2) The possibility of the firm's exit drives an important prediction in both classes of model: compensation rises in dying firms. (3) The firm's exit decision may be distorted. These result illustrates the need for careful attention to the circumstances under which valuable jobs are liquidated.

Joseph A. Ritter
Research Officer
Federal Reserve Bank of St. Louis
411 Locust Street
St. Louis, MO 63102

Lowell J. Taylor
Heinz School of Public Policy
and Management
Carnegie Mellon University
Pittsburgh, PA 15213

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Agency problems pervade the relationship between employers and employees. Merely paying a worker the amount she requires to forego leisure today does not typically guarantee that her behavior in the workplace will maximize the profits of the firm. This tension between allocative and productive efficiency forms the basis for several models of compensation, including tournaments, tenure-earnings profiles, and efficiency-wage models. The hallmark of these approaches is that firms use various mechanisms to give workers' jobs positive value.

These models generally incorporate exogenous separation at a fixed rate, capturing in a crude way the idea that the stability of the job affects the level of observed compensation. Little attention has been given to the link between variation in the firm's circumstances and its compensation policies. Theories connecting agency problems and compensation typically consider dismissal only in connection with its use as a trigger strategy or "worker discipline device" (Lazear, 1981; Shapiro and Stiglitz, 1984). But, of course, when a firm's circumstances change, it may need to dismiss employees for reasons not connected with worker discipline. We argue here that this simple observation has important and inescapable consequences for understanding how compensation schemes (theories) function when the firm's environment is stochastic.

In a previous paper (Ritter and Taylor, 1994) we demonstrated that uncertainty and private information about the firm's future—and therefore the future of jobs—could change the equilibrium compensation scheme. In this paper we follow a more direct course, constructing models which describe explicitly the links between uncertainty in a firm's environment and its compensation policy. Firms face stochastic demand or productivity shocks and simultaneously determine wages, labor demand, and exit.

In subsequent sections we construct a model of compensation for a monopolistically competitive firm that faces stochastic demand or productivity. A simple asset-pricing structure links the firm's prospects with compensation structures that resolve agency problems by making jobs valuable. In particular, we study efficiency-wage and performance-bonding models that are nested in a more general model. In both cases workers' jobs have positive value, and our main purpose is to illustrate features which derive from this characteristic. While standard deterministic versions of these models predict that compensation will depend on characteristics of the job and worker, the stochastic versions we study demonstrate that observed levels of compensation also depend systematically on characteristics of the firm and its environment, even when firms can effectively use bonding strategies.

The performance-bonding version of our model highlights the equivalence between the efficiency of bonding solutions and the conditions required for strict adherence to Modigliani-Miller propositions. (Many criticisms of the bonding approach to regulating workers' behavior amount to claims that the strict conditions do not hold.) In contrast, efficiency-wage models explicitly assume the existence of frictions that block a first-best solution. Consequently, efficiency wages systematically distort the firms' actions on dimensions other than wages and employment.

The most striking commonality between the bonding and efficiency-wage models is that in "bad" states of the world (weak demand or low productivity) the rate of return on the job—the efficiency wage premium or return on the performance bond—must rise to compensate the worker for potential loss of the capital value of the job. To put it bluntly, it is difficult to give high value to a job that is likely to vanish in the near future. This observation puts clear restrictions on the returns that must be promised on bonds, raising observed compensation (which includes repayment of bonds) in bad states. In efficiency-wage models wages must rise rapidly as the firm nears exit. It is important to note that this phenomenon is *not* a manifestation of risk aversion (which is not present in our model), but rather a robust implication of the internal economic logic of models that resolve agency issues by attaching value to jobs.

A consequence of the need to maintain a job's value in bad states is that when it is costly to do so—as it is in efficiency-wage models—the firm's exit decision is distorted in a particularly interesting way: The firm shuts down when the value of ownership claims drops to zero, but this occurs when the firm still has some residual value embedded in workers' claims to a stream of wage premiums. (A firm that could costlessly resolve its agency problems would not shut down in this state.)

The information asymmetry that generates the agency problem in the first place makes it impossible to preserve this value through simple transfers between workers and the firm. Employers and employees are in the difficult position of seeking to structure worker concessions that continue to satisfy incentive constraints. In the final section of the paper we turn to the issue of how the residual value found in a dying firm can trigger a struggle to find ways to preserve that value.

1. An Effort-Regulation Model

Many models of compensation rely on some form of performance bonding. Bonding, where possible, allows the firm to reproduce the allocations of the neoclassical model in the face of various agency problems. In Lazear's (1981) model of tenure-earnings profiles, for example, the average wage over the worker's lifetime and average value of marginal product equal the spot market wage. Efficiency-wage models start from the premise that bonding can only partly solve the firm's agency problems. If the agency problem is serious enough to make a costly solution worthwhile, the firm pays a wage that exceeds the spot market wage at every date. Thus firms should prefer bonding where it is feasible. But various arguments against universal applicability of bonding have been advanced. See, for example, Akerlof and Katz (1989), Dickens, Katz, and Lang (1989), and Ritter and Taylor (1994).[1]

[1] If incentive pay can be used effectively in a firm, these papers and the present paper

The model we develop here nests both approaches.

We consider a firm with a work force of infinitely-lived workers. The firm is a monopolistic competitor facing demand curve

$$Y_i = A_i P_i^{-\eta}.$$

A_i follows an S-state, irreducible, aperiodic Markov chain with transition matrix $M = [\mu_{ij}]$. We will choose M so that the stochastic process for A_i approximates a stationary, normal AR(1) process. Our model is thus intended to capture a firm's response to stationary variation in its environment, not permanent shifts in its prospects. The values of A are ordered so that $A_i < A_j$ if and only if $i < j$. We assume that for some values of A the firm is not profitable.

The firm produces output using labor and a fixed amount of capital according to the production function $Y = \theta L^\alpha$ with $\alpha < 1$. We assume that the capital requires a fixed rental payment F per period. We assume that the firm hires labor to the point where the value of marginal product equals the wage:

$$L_i = \left(\frac{\alpha\theta P_i}{W_i}\right)^{\frac{1}{1-\alpha}}.$$

This assumption simplifies our analysis by implicitly ruling out wage and labor demand policies conditioned on anything beyond the current value of the state variable A_i. We have more to say on this subject below. The productivity parameter θ and A_i enter the problem in a mathematically similar way, so our conclusions also apply to a model with stochastic production technology where A is constant and θ follows a Markov chain.[2] The firm may choose to shut down in any state, and faces neither entry nor exit costs.[3]

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are largely irrelevant, but the difficulties facing incentive-pay systems are manifold (Gibbons, 1996).

[2] If the firm is a price taker, a stochastic P and stochastic θ are mathematically identical, entering the problem only as $P_i\theta_i$.

[3] Our formulation admits entry and exit costs fairly easily. Although these would

We adopt a simple effort-regulation setup that allows us to calculate the wages required to solve the firm's agency problem for an arbitrary level of bonding. In subsequent sections we examine a pure efficiency-wage case, which assumes that no bonding is possible, and a pure bonding case, which assumes that bonds can be large enough to solve the agency problem without any efficiency-wage premium. (The polar cases illustrate the implications of the respective theories. In practice, however, we believe both approaches can coexist, with efficiency wages used to fill gaps that, for one reason or another, bonding solutions cannot.) Workers can work at high or low effort levels, which we normalize to e^h and 0, respectively. The worker's effort level is not directly observed by the firm. We assume that it is never profitable for the firm to operate at the low effort level. Workers' utility per period is given by $w - e$ where w is the wage and $e \in \{0, e^h\}$. Firms and workers share a common discount factor $\beta < 1$.

Each date t is divided into five stages:

1. A new state A_i is revealed.
2. The firm sets wage W_i and hires labor L_i, laying off workers as necessary.
3. Performance bonds posted in $t - 1$, if any, are repaid with interest. New bonds, if any, are posted.
4. Workers choose effort levels. Production takes place. Wages are paid.
5. The firm receives a signal ϵ about the worker's effort level. Workers are terminated for cause, as necessary.

If labor demand declines ($L_j(t) < L_i(t-1)$), existing workers face permanent layoff with equal probability.[4] Otherwise they are retained. Given demand level A_i

add minimal complexity they seem unlikely to interact in an interesting way with the problem of designing compensation policies. Their addition would, however, complicate interpretation of our results, particularly those pertaining to the firm's exit choice.

[4] In Ritter and Taylor (1998) we argue that seniority-based layoff policies can function as a partial bonding mechanism when labor demand is stochastic.

in $t-1$ and A_j in t, the probability of retention in t is

$$\lambda_{ij} = \min\left\{\frac{L_j}{L_i}, 1\right\}.$$

We assume that laid-off workers lose their entire bond, that is, they get no severance pay. This assumption is implemented by setting the gross return on the bond to zero. We discuss this assumption in more detail below.

The signal ϵ reports $\epsilon = 0$ with probability d given $e = 0$. Otherwise $\epsilon = e^h$. If $\epsilon = 0$, the worker is fired. Fired workers also lose their entire bond.

1.1 The Probability Distribution of Continued Employment

We begin our analysis of this model by considering the problem faced by the worker in stage 4. Suppose J is the index of the minimum operating state, that is, the firm shuts down when $A < A_J$. Workers treat J as a parameter and recognize that $\lambda_{ij} = 0$ for $j < J$. When $A_J < A_j < A_i$, $0 < \lambda_{ij} < 1$. With the production function and demand curve we have chosen,

$$\lambda_{ij} = \left(\frac{A_i}{A_j}\right)^{\frac{1}{\alpha+\eta-\alpha\eta}} \left(\frac{W_i}{W_j}\right)^{\frac{-\eta}{\alpha+\eta-\alpha\eta}}, \qquad i > j \geq J.$$

The two sources of uncertainty for workers (shocks to the firm and the randomizing device that determines which workers get laid off) induce another, more complex Markov chain that describes the stochastic structure of the worker's problem. We promise the reader that the complexity introduced in the next two paragraphs is repaid with considerable subsequent simplification.

Let Λ^J be the $S \times S$ matrix containing λ_{ij} (for a minimum operating state A_J) and let $\odot$ denote element by element multiplication. Our assumptions on the firm's state and layoffs jointly generate a Markov chain with the following $2S \times 2S$ transition matrix:

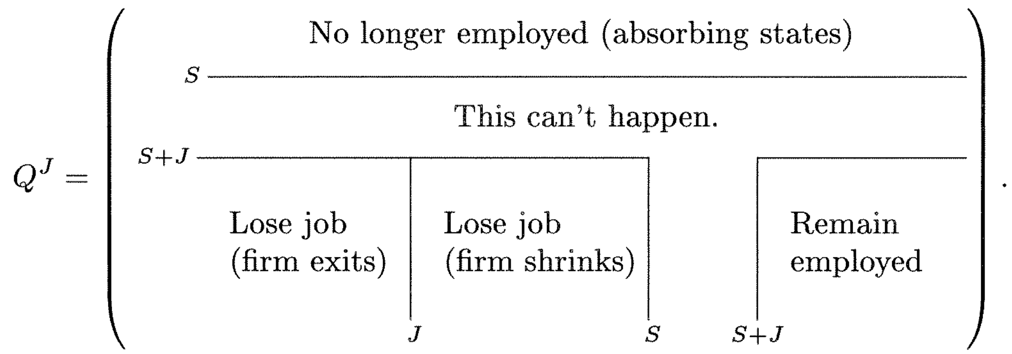
$$Q^J = [q_{ij}^J] = \begin{pmatrix} I & 0 \\ M - \Lambda^J \odot M & \Lambda^J \odot M \end{pmatrix},$$

where the identity matrix is $S \times S$. Subsequently, we suppress the J superscript where this causes no ambiguity. The first S states correspond to different values of A, conditional on *past* termination of the job. (These states function as a single absorbing state in terms of the economics, but carrying around S separate but equivalent absorbing states keeps the form of Q simple.) The second S states represent different demand states, given that the worker retains her job. A typical element of the lower right submatrix is $\mu_{ij}\lambda_{ij}$, i.e., the probability that demand goes from A_i to A_j times the probability that the worker retains her job in this transition. A typical element of the lower left submatrix is $\mu_{ij}(1 - \lambda_{ij})$; the same demand shift, but the worker loses her job.

States $S+1$ through $S+J-1$ correspond to the events that $A < A_J$ (the firm exits) *and* the worker retains her job, and therefore do not occur. Because those states cannot be reached, they have no influence on the solution of the worker's problem. It will, nonetheless, be convenient, subsequently, as we vary J, to keep these states in the matrix in an appropriate way. We do so by setting to 0 every element except the diagonals in the $S+1$ through $S+J-1$ rows and columns. The diagonals equal 1. In other words, the lower-right partition of Q has the following structure:

$$\Lambda^J \odot M = \begin{pmatrix} I & 0 \\ 0 & \widehat{Q} \end{pmatrix}.$$

For transitions within $\widehat{Q}$ (which is $(S - J + 1) \times (S - J + 1)$), the worker continues to be employed. All of the other nonzero elements in the last $S - J + 1$ rows of Q represent transitions to unemployment. Informally, the structure of the transition matrix faced by the worker is:



For the remainder of the paper, state indices will refer to the $2S$ states in Q, except when referring to A or elements of M.

1.2 No-Shirking Condition

We denote the expected value of the unemployed state by V^u. Since V^u does not depend on the firm's state, we are implicitly assuming that a worker laid off by this firm is no more likely than any other unemployed worker to be employed by this firm in the future. The bond posted in state i is B_i (with the convention that $B_i = 0$ for $i < S + J$). At this stage we are considering an arbitrary B_i. The gross rate of return on a bond posted in state i and repaid in state k we denote R_{ik}. Our assumption that workers get no severance pay implies $R_{ik} = 0$ if the worker is laid off (that is, $k \leq S + J$). The worker's expected lifetime utility in state i is V_i if the worker chooses $e = e^h$ and V_i^0 if she chooses $e = 0$. By convention we let $V_i = V_i^0 = V^u$ for $i < S + J$. Then for an employed worker ($S + J \leq i \leq 2S$),

$$V_i = W_i - e^h - B_i + \beta \sum_{k=1}^{2S} q_{ik}[V_k + R_{ik}B_i], \tag{1}$$

$$V_i^0 = W_i - B_i + d\beta V^u + (1-d)\beta \sum_{k=1}^{2S} q_{ik}[V_k + R_{ik}B_i]. \tag{2}$$

The first of these equations says, for example, that a worker who does not shirk in state $i \geq S + J$ (a state in which the firm is still operating and the worker is still employed) receives current utility $W_i - e^h$.[5] With probability q_{ik}, next period's state is k. If $k \leq S$, the worker's job is terminated ($V_k = V^u$ and $R_{ik} = 0$). In the second equation a shirker is detected and loses the job with probability d.

We are interested in wage-bond policies which induce workers to provide high effort. To derive no-shirking conditions, we consider a one-period deviation from a high-effort policy. This is why V_k rather than V_k^0 appears on the right-hand side of (2). Using one-period deviations is necessary to allow the possibility that, for a given wage profile, shirking will be optimal in some states but not others.

Risk-neutral workers require that the expected return on the bond equal the risk-free rate R^F. The vector of returns promised when the state is currently i, R_i, must satisfy

$$R^F = Q_{i\bullet} R_i, \tag{3}$$

where $Q_{i\bullet}$ is the ith row of Q, and $i \geq S + J$ (the firm is operating and the worker is employed).

As a notational device, define $z \equiv (1-\beta)V^u$. If workers losing jobs can immediately find low-effort work, the competitive wage will be z, but this interpretation is not necessary, except in determining the behavior of a firm that does not face agency problems. Let $V = [V_1, \ldots, V_{2S}]'$, $V^0 = [V_1^0, \ldots, V_{2S}^0]'$, $B = [B_1, \ldots, B_{2S}]'$, $U = [z, \ldots, z, W_{S+J} - e^h, \ldots, W_{2S} - e^h]'$, and $U^0 = [z, \ldots, z, W_{S+J}, \ldots, W_{2S}]'$. Equation (3) implies that $\sum_{k=1}^{2S} q_{ik} R_{ik} B_i = R^F B_i$ in (1) and (2). Using this observation, (1) and (2) can be written for all i as[6]

$$V = U - B + \beta R^F B + \beta Q V \tag{4}$$

$$V^0 = U^0 - B + d\beta \widetilde{V}^u + (1-d)\beta R^F B + (1-d)\beta Q V$$

where $\widetilde{V}^u$ is a $2S \times 1$ vector in which every element is V^u.

5 Our convention is that V_i is the worker's expected utility after the bond is posted.

6 Most of the equations in this system are redundant: $V^u = z + \beta V^u$. The tractability of this system is the reason for all of the rigamarole in defining Q and z.

Suppose that the firm offers an arbitrary implicit contract $\{w, B\}$. Then the worker will provide effort level e^h whenever employed if

$$0 \leq V - V^0 = (U - U^0) - d\beta V^u + d\beta R^F B + d\beta QV. \tag{5}$$

2. Efficiency Wages

A pure efficiency-wage model assumes that $B_i = 0$ for all i. Only the wage is used to elicit effort. The no-shirking condition (5) reduces to

$$0 \leq (U - U^0) - d\beta V^u + d\beta QV. \tag{6}$$

Setting $B = 0$ in (4) implies $V = (I - \beta Q)^{-1} U$. Using this in (6) yields the following useful form of the no-shirking condition:[7]

$$U = (1 - \beta)V^u + \left[I - (\beta Q)^{-1}\right] \frac{U - U^0}{d}. \tag{7}$$

Since the firm faces neither entry nor exit costs, it exits when current profits are 0. Since the profits of the firm depend on the wages it must pay, and the wages it must pay in turn depend on the exit state, the exit decision is not trivial.

Fortunately, however, (7) does not depend on the firm's profits, only the exit state. Given minimum operating demand A_J, the last $S - J + 1$ equations in (7) determine the $S - J + 1$ wages $W_J, \ldots, W_S$. (Recall that labor demand and, therefore, Q (via Λ) depend on the current wage, so the system is nonlinear.)

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[7] For numerical purposes the relevant portion of (4) is the last $S - J + 1$ equations, which can be written

$$U = (1 - \beta)V^u - \frac{e^h}{d} + (\widehat{\Lambda} \odot \widehat{M})^{-1} \frac{e^h}{d\beta},$$

where $\widehat{M}$ and $\widehat{\Lambda}$ are the $(S - J + 1) \times (S - J + 1)$ submatrices in the lower right corners of M and Λ. Because of the block-diagonal structure of Q, $(\widehat{\Lambda} \odot \widehat{M})^{-1}$ equals the corresponding submatrix of Q^{-1}.

The following simple solution procedure presents itself: 1) For each possible J, find the vector of wages W^J that solves (7). 2) Calculate profits in J and $J-1$. 3) The firm's minimum operating state is the smallest J such that profits are negative in state $J-1$ and nonnegative in J.[8]

2.1 Numerical Solutions

The most important choice for our numerical solutions is the transition matrix M. Following Tauchen (1988), we use a class of matrices for which the Markov chain approximates an AR(1) process in A with normal innovations.

$$A(t) = \rho A(t-1) + \epsilon(t),$$

where $\epsilon(t) \sim \mathrm{N}(\overline{A}, \sigma_\epsilon^2)$. Tauchen's procedure constructs a transition matrix for a Markov chain whose domain spans a fixed number of standard deviations of A on either side of its mean. We use four standard deviations and 301 states. Values of A range from 0.0001 to 5.6.[9] The unconditional mean of the process is state 151 in every case. We experimented with a variation in which the Markov chain approximates an AR(1) process in $\ln(A)$. This choice does not affect the transition matrix, only the prices that correspond to the states. Results were broadly similar in this log-normal case. Results were also very similar in the case where θ rather than A follows a Markov chain.

We used two main criteria for choosing parameters. First, the range of A considered must include the firm's shutdown level. Second, we chose parameters so

8 With a large number of firms facing independent and identical stochastic processes for A, V^u would be constant and exogenous to the firm, but endogenous to labor market equilibrium. It would still depend, however, on an assumed level of utility of unemployed workers, and would, therefore, still be effectively a free parameter, so we do not solve for labor market equilibrium. Our qualitative conclusions do not depend on the value of V^u.

9 In Figures 2 and 3 which compare stochastic processes, we vary Tauchen's procedure by forcing the range of values of A to remain the same as in our baseline case. This effectively makes the approximation better for one process, but with a fine state space, the difference is unimportant.

that the shutdown level in the baseline was below the mean. Our baseline solution in Figure 1 uses $\rho = 0.7$, $\sigma_\epsilon = 0.5$, $d = 0.25$, $\beta = 0.97$, $\eta = 2$, $\alpha = 0.67$, $\theta = 1$, $F = 0.25$, $e^h = 1$, and $z = 5$.

The solution shown in Figure 1 is typical. Mean reversion in the stochastic process for A means that workers need to worry about job loss both when demand is strong and when the firm is weak. When the firm's demand is very low, there is a significant chance of exit. Even though this would be a move away from the mean, the expected loss from the event is high. Workers must therefore be paid a substantial premium in these circumstances if the value of the job is to be maintained. The figure also indicates that the state in which a neoclassical firm would shut down (zero profits with $W = z + e^h$) is below the optimal shutdown for an efficiency-wage firm. This is partly because efficiency wages are always higher than the competitive level $z + e^h$, even in a deterministic model. But here, the firm faces a dilemma: As A approaches the shutdown state, wages rise dramatically. Even without this effect, the usual efficiency wage premium would cause the firm to exit at an inefficiently high A. This "endgame effect" induces the firm to exit even sooner. Since there are no entry or exit costs the firm need not worry about preserving any real options, so this effect comes exclusively from the efficiency-wage mechanism.

It seems paradoxical at first that workers also require a wage premium when demand is unusually strong, but a bit of reflection reveals this to be a consequence of mean reversion. When A is far above its mean, workers recognize the likelihood of significant layoffs as it drifts back toward its normal level.[10] Figure 2 illustrates this effect by comparing three solutions with different degrees of mean reversion, holding the unconditional variance of A constant (that is, we adjust σ_ϵ^2 so that $\sigma_A^2 = \sigma_\epsilon^2/(1-\rho^2)$ does not change). With a lower ρ (more mean reversion) wages

[10] This effect is magnified when A has log-normal innovations because a given degree of mean reversion in $\ln(A)$ corresponds to larger movements in A and thus larger changes in labor demand and larger layoffs when A is above its mean.

rise more steeply as A rises above its mean. When ρ is lower, the probability of exit is lower in operating states below the mean, since mean reversion "pulls" the state away from the shutdown point. Mean reversion "pulls" better states towards shutdown, but this has an insignificant impact on the wage because the probability of a negative innovation large enough to induce exit is very small.[11] For lower values of ρ, therefore, wages rise less steeply as the firm nears shutdown. This also means that the exit state is lower—closer to the efficient point—with small ρ. Roughly midway between shutdown and the mean, wages can be especially low for lower ρ because the probability of layoffs not associated with exit is low (since these do not occur when A increases, which it is likely to do), while the possibility of immediate exit is fairly remote.

The skewed U-shape of the product demand–wage profile suggests that the firm might find it worthwhile to offer to limit variations in employment, that is, to hoard labor, in order to control wage costs when demand is either especially low or especially high. This is true in a limited sense in the present model: Labor demand is less responsive to the state in the efficiency-wage model than in a neoclassical model, except near exit.

We assumed in Section 1 that the firm stays on its marginal revenue product curve (the usual assumption in efficiency-wage models), but a firm might want to lower the efficiency wage by promising to further limit employment variation by operating off the marginal revenue product curve in some states. Modeling that insight requires careful attention to strategic considerations, however, since the firm always wants cheat in the short run by operating on its value of marginal product

[11] If A were i.i.d., the probability of shutdown, conditional on A_t would exactly equal the unconditional probability, so a low price in t would indicate nothing about the likelihood of shutdown in $t+1$. This does not mean that wages are constant: Although the probability of exit is constant, the probability of layoff is higher for higher A. Thus, paradoxically, with a very high degree of mean reversion (low ρ) workers can feel more secure when their firm is near exit than when it is booming.

curve as we assume here. To do so would take us far afield. Here we simply note that: (1) The solution we use here is the subgame perfect equilibrium in which workers do not believe the firm will ever resist the temptation to move employment onto its value of marginal product curve. (2) The firm cannot use a labor-hoarding strategy to completely eliminate the rise in wages near shutdown; there must be some A below which the firm fires workers, and when the probability of this event rises, so will wages.

As shown in Figure 3, the main effect of increasing σ_ϵ is to increase the wage premium paid near shutdown and, since higher wages make the firm less profitable in a given state, exit occurs at a higher level of A. These effects are driven by the fact that a higher innovation variance raises the probability of crossing a given exit threshold from any given state. The solutions converge for higher values of A because the probability differential becomes trivial in states far from exit.

Variations in the monitoring parameter d, shown in Figure 4, change the solution in the same way predicted by deterministic efficiency-wage models, but the greater probability of job loss when A is either very low or very high increases the differential paid to workers in low-d firms. Low d also distorts the firm's exit decision more than a high d. The technology of monitoring workers is something that is, in reality, at least partly endogenous. As we discuss below, this is a particularly interesting margin for a firm that is near exit, so the extra sensitivity of wages to d near exit and the sensitivity of the exit threshold itself are of special interest.

2.2 Implications for Compensation Patterns

There are two additional implications for compensation patterns that are worth attention. First, in this model wages are a function not merely of job characteristics (d, for example), but also firm characteristics (α, θ, and the stochastic process for A). The importance of this observation stems from a weakness of standard efficiency wage models: The wage dispersion predicted by the theory does not accord well with certain aspects of empirically observed wage patterns. In the standard deterministic shirking model, wage differentials result from differences in the difficulty of monitoring worker effort in a particular task. Thus workers performing a particular job ought to be paid about the same in all industries and by all firms. Empirically, however, there tends to be a high cross-occupation correlation of wages in industries and firms; firms that pay high wages in one job are often observed to pay high wages in all jobs (Katz and Summers, 1989; Dickens and Katz, 1987; Groshen, 1991). It appears that the rents some workers earn are related to the characteristics of the *firm*, not merely characteristics of the job. Our model predicts that the nature of the firm's product market and/or its idiosyncratic productivity (θ) exerts systematic influence over compensation.

Second, although we are skeptical of the prediction that firms on the verge of bankruptcy pay extraordinarily high wages, it does seem plausible that firms that can offer generally better future prospects (because current demand or productivity is strong, for example) find themselves able to pay lower wages. To the extent that demand or productivity shocks are correlated across firms so that weak demand tends to indicate a weak economy overall, the high wages associated with weak demand impart a countercyclical impulse to real wages. When the source of uncertainty in our model is V^u rather than A, real wages are procyclical, as suggested by simple comparative statics on deterministic efficiency-wage models. There are thus opposing forces working on the cyclicality of the real wage, one of which is neglected by deterministic models.

3. Performance Bonds in a Modigliani-Miller World

We now turn to the case where agency problems can be costlessly resolved by use of performance bonds. After the bond is posted it becomes a liability of the firm and an asset in the worker's portfolio. The rate of return on the bond must, therefore, meet some portfolio equilibrium conditions. In general, the nature of the conditions depends on the nature of financial markets and the risk preferences of the worker. In this paper we pursue the matter in the simplest way by assuming risk-neutral workers, giving us the single rate-of-return condition, (3).

In this section we assume further that the firm operates in an essentially frictionless environment, where the value of the firm and the economy-wide equilibrium are essentially unaffected by the firm's use of performance bonding. In particular we assume that (1) both entry and exit are costless, (2) financial markets are complete and efficient from both the firm's and the worker's points of view, (3) there are no transactions costs in either labor or financial markets, and (4) there is no income taxation. Failure to meet any of these conditions is likely to make bonding a costly way to resolve the agency problem.

3.1 No-Shirking Condition

If a firm uses exclusively bonds to regulate effort, the no-shirking condition (5) can be solved explicitly for B. First, the wage is determined by external labor market equilibrium and therefore does not depend on the firm's state. Since we are assuming no macroeconomic uncertainty the wage is constant. In this full-bonding solution, the worker gets no surplus from the job so that $V = \widetilde{V}^u$. Let bond B_i be just large enough to induce $e = e^h$ in state i. Exploiting the fact that Q is a probability matrix and therefore has an eigenvector $[1, 1, \ldots, 1]'$ and corresponding eigenvalue 1, we have

$$B = \frac{U^0 - U}{R^F d\beta}.$$

For states in which the worker is employed ($i \geq S + J$), the bond is constant:

$$B_i = \frac{e^h}{R^F d\beta}.$$

For $i < S + J$, $U^0 = U = z$, so $B_i = 0$ as expected. Thus, all of the effects of uncertainty work through the rate of return (equation (3)) rather than the size of the bond.

3.2 The Structure of Returns

The theory behind performance-bonding models leaves extensive indeterminacy about the structure of returns on the bond.[12] Under risk-neutrality, the firm and workers can agree on any pattern of state-specific payoffs that satisfies (3). The logic of bonding limits the range of assets the firm can force the worker to hold, but does not uniquely determine the state-specific payoffs. It is necessary to make some further restrictions in order to construct specific bonding schemes.

As mentioned above, we maintain two core hypotheses about the structure of returns: (1) $R_{ik} = 0$ if $k < J$, that is, a worker loses her entire bond if the firm exits; and (2) $R_{ik} = 0$ if $J \leq k < S$, that is, she loses her entire bond if laid off, even when the firm does not exit. We separate the two because the first is critical to much of our argument, yet uncontroversial.

The second assumption is probably unrealistically strong, since layoffs may be temporary and severance pay is sometimes observed. Most of our qualitative results would be retained if there were complete loss of the bond only when the firm exits. We think, however, that for many bonding arrangements discussed in the literature and their empirical counterparts, it is reasonable to assume that any job loss results in some capital loss for the worker. Lazear (1979) assumes complete loss for workers who lose their jobs because the firm shuts down (which he subsumes

[12] Lazear (1981) noted that this indeterminacy makes various lifetime earnings profiles indistinguishable on a theoretical basis.

in an exogenous probability of "cheating"), but argues that severance pay equal to the accumulated value of deferred compensation could allow efficient separations of other types. This may be a significant consideration for firms (Lazear argues that it helps explain early retirement incentives). Nonetheless, we see three reasons to suspect that severance pay arrangements do not generally compensate workers fully for job loss.

First, any repayment of bonds upon termination would require a verifiable distinction between dismissal for cause and any other layoff. This seems inconsistent with the spirit of implicit contracts; firms would prefer to hold bonds in escrow accounts, obviating most of the moral-hazard problems they ordinarily must face. Second, the only systematic data on severance pay we are aware of show severance pay in collective bargaining agreements rising with seniority (Pita, 1996), rather than rising and then falling as intertemporal bonding models would imply. If these agreements are efficient, the relationship between tenure and severance payments should still be hump-shaped, with surplus shared in ways that do not distort separation incentives. Third, workers clearly dislike involuntary separations, *ex post*, though, of course, this could be because they lose claim to rents from some source such as union power or efficiency wages.

We add a third assumption that pins down a simple return structure. Suppose the firm promises that, conditional on continued employment, bonds posted today in state i pay the same return in all future states k, that is, $R_{ik} = \overline{R}_i$ for all $k \geq S+J$ and $R_i = [0, \ldots, 0, \overline{R}_i, \ldots, \overline{R}_i]'$. In this case (3) reduces to

$$\overline{R}_i = \frac{R^F}{\sum_{k=S+J}^{2S} q_{ik}} \tag{8}$$

Since the worker loses her bond whenever she loses her job, not only when the firm exits,

$$\overline{R}_i > \frac{R^F}{\sum_{j=J}^{S} \mu_{ij}}$$

The right-hand side is the rate the firm must pay on ordinary debt liabilities, assuming the firm has no valuable assets at exit. (Recall that the μ_{ij} are transition probabilities for A.) As the firm's situation deteriorates, its ordinary corporate debt takes on junk status (provided the state is positively autocorrelated), but the worker's claims are even less attractive, since (1) they can lose their jobs before exit and (2) they have *no* claim on residual assets of the firm.

On the surface it might appear unlikely that there are no substantive consequences to the existence of such dramatically structured liabilities, but in a frictionless environment the Modigliani-Miller logic applies: the financial structure of the firm in general and the structure of this security (the performance bond) in particular do not affect the value of the firm or general equilibrium allocations of resources. Performance bonds achieve first-best outcomes.

3.3 Potential Frictions and Distortions

In the remainder of the paper we treat the performance-bond model as a frictionless baseline, but since controversies about performance bonds have rarely been framed in an explicitly stochastic setting. A brief digression that highlights the special features of performance bonds seems worthwhile. A number of these features appear particularly germane to whether performance bonds can distort the firm's behavior. First, asymmetric information can make bonding costly. In an earlier paper (Ritter and Taylor, 1994) we argued that when firms have private information about their own prospects, "safe" firms—those with higher probability of continued employment—have an incentive to use a costly signal, namely efficiency wages, to distinguish themselves. This line of reasoning is similar to the signaling role of dividends hypothesized by Bhattacharya (1979).

Second, since workers have no legal recourse if the firm does not honor its obligation, the security issued to workers is more similar to preferred stock than to debt. Accordingly, performance bonds would not have the salutary effect on managerial effort that has been attributed to debt (Jensen, 1988).

Third, the security is dissimilar to ordinary securities in that workers have *no* legally enforceable claim to, say, high wages late in their careers. This makes these claims particularly susceptible to opportunistic behavior on the part of the firm through "downsizing" or "restructuring." These activities appear to be the labor market equivalent of Chapter 11 proceedings. This is just the old moral hazard criticism of performance bonding dressed up in new clothing, but the analogy highlights an useful observation: Whether layoffs result from moral hazard or are simply the realization of contingencies that were mutually understood, *ex ante*, there is likely to be costly conflict and negotiation surrounding them, just as there is costly conflict surrounding Chapter 11 proceedings.

Fourth, risk aversion will make bonding costly, if workers cannot insure against loss of the bond. Since the reason for the bond in the first place is moral hazard, this seems most plausible. In fact, the worker bears more risk than the firm's creditors; even the least risky performance bond, priced in (8), is stochastically dominated (in the second order) by ordinary debt.

3.4 Implications for Compensation Patterns

Bonding schemes that are taken seriously as models of compensation (e.g., life-cycle incentives or tournaments) embed the posting and repayment of bonds in the stream of compensation. In this section, therefore, we identify wages plus net bond repayments with the term "observed compensation." We assume that the firm pays a gross return of $\overline{R}_i$ to each employee it continues to employ.

Our main point is intuitively clear from (3), though we give a numerical illustration in Figure 5, using the same parameter values as the baseline efficiency-wage solution. If the state is positively autocorrelated, a firm facing low demand, say A_J, has poor future prospects. In particular, for most natural stochastic specifications the probability of exit tomorrow, given demand A_J today, $(\sum_{k=1}^{J-1} \mu_{Jk})$ is higher than the probability of exit tomorrow if today's demand is A_{J+10} $(\sum_{k=1}^{J-1} \mu_{J+10,k})$. This is certainly true, for example, when we structure M so that $A(t)$ approximates a Gaussian AR(1) process. Since the worker loses her bond whenever there is a transition to $A_k < A_J$, she will require higher returns when posting a bond in J than when posting a bond in $J+10$: $\overline{R}_{S+J} > \overline{R}_{S+J+10}$.[13]

If today's state is poor, it is likely that yesterday's state was also poor, so observed compensation today is likely to be high. The opposite is true for good states. The slope of an intertemporal compensation path depends on its history. Compensation paths will slope downward for firms recovering from near-death experiences (including, possibly, birth), since the rate of return declines (with a one-period lag) as the state gets farther away from exit. Firms on the decline see steeply rising compensation. In principle, more complicated repayment patterns, such as those proposed by Lazear, can be treated as portfolios of bonds posted at different dates with varying maturities and returns, but the indeterminacy mentioned above makes none seem compelling (since life-cycle incentives are not meaningful in our model).

Two basic messages would not change with more complicated patterns. First, the promised rate of return always exceeds that promised to ordinary bond holders. Second, firms that ask employees to post bonds when they are likely to be lost must offer higher rates of return. In short, observed compensation tends to be high when the firm is on the ropes.

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[13] Because of the general indeterminacy of the pattern of bond repayments, it is possible to construct bonding schemes that do not have this property, for example, $R_{ik}B = \gamma_i \pi_k$ where π_k is the value of the firm's profits in state k and γ_i is the fraction of them promised in state i to a worker who remains with the firm in the next period. In this model γ_i turns out to be very high for bad states and low for good states. Observed compensation is low in bad states because π_k is low, but correspondingly enormous in good states. The time path of compensation is also very complex.

4. The Dying-Firm Dilemma

The influence of compensation on the exit margin and the influence of exit on compensation are of interest in their own right, but they open a deeper set of intriguing issues, which we begin to address in this section. The deeper issues arise because the prospect of immediate liquidation can trigger a search for ways to preserve value in the firm.

The nature of the situation is as follows: Firms sometimes find themselves perilously close to shutdown and, taking literally the predictions of our model, they must pay particularly high compensation, if jobs are to remain sufficiently valuable to induce high effort. In the efficiency-wage setting, rising wages reduce profits rapidly, and exit occurs when profits are zero. Although we find this logic compelling, the implication that firms rapidly increase compensation when they are on the verge of bankruptcy strikes us as generally counterfactual.[14] Such a situation is obviously rather fluid, and outcomes vary from firm to firm, but two broad approaches seem to offer insight into what actually happens. First, firms are able to adjust on margins we have suppressed in the interest of (relative) simplicity. Second, a critical situation might present opportunities for some form of "renegotiation" of implicit contracts.

4.1 Adjusting on Other Margins

Our model makes the stark assumption that firms find it efficient to induce the same effort level, regardless of the state. A more general formulation would allow continuous effort choices. In the efficiency-wage case, the higher wage necessary in bad states would make a lower effort level optimal. The reduction in effort is accomplished simply by reducing the wage. This story accords well with the obser-

[14] There is evidence that workers in industries that have high unemployment risk receive wage premiums (Abowd and Ashenfelter, 1981). This evidence is related to the point at hand, but we know of no systematic longitudinal evidence that firms tend to increase wages as they near bankruptcy.

vation that morale tends to deteriorate in dying firms. It is also possible that when market fundamentals are particularly weak, the marginal value of effort declines for some firms.[15] In the performance-bonding case the compensating-differentials portion of the wage would decline, and the total payment on the bond would be smaller, since the bond necessary to prevent shirking would now be smaller. Thus, a continuous-effort generalization could quantitatively reduce the large rise in compensation observed in states near exit.

This generalization would not, however, alter the qualitative conclusion unless the firm chooses to adjust exclusively on the effort margin. Similar reasoning would apply if a firm could pay to adjust d at the margin by, say, hiring more supervisors. Moreover, a firm using only bonds does not adjust on either margin unless the value of marginal effort is negatively correlated with the state, allowing it to adjust the compensating differential paid for effort.

Along much the same lines, a firm that uses its compensation scheme to regulate turnover might be willing to tolerate higher turnover to save on wages. Again, the story accords well with observation: firms with an uncertain future tend to exhibit high turnover.

4.2 Can Workers in Dying Firms Make Concessions?

Though both efficiency-wage and performance-bond firms must, in bad states, provide relatively high compensation to resolve the effort regulation problem, there is a fundamental difference between these cases. No meaningful concessions are possible in frictionless performance-bond firms, but in principle they are possible in an efficiency-wage firm.

Consider first a performance-bond firm that has the ill fortune to arrive in a zero profit state, say $(J-1)$. Workers who lose their bonds will be unhappy about this

[15] For example, an airline facing a reduction in the demand for seats might find it optimal to allow agents at the ticket counter to work at more leisurely pace.

turn of events, but there is no action that either party would be willing to take that would reverse this outcome. The firm has zero value under the existing implicit contract, which specified $R_{i,J-1} = 0$. If the firm agreed to partial repayment of the workers' bond (thus preserving some of the job's value), the value of the firm becomes negative. Workers are, of course, unwilling to accept a negative return $R' < R_{i,J-1} = 0$, since that would make the value of their jobs negative. Furthermore, since no restructuring of the firm's liabilities can change the value of the firm, more complicated concessions (deferring repayment until demand exceeds A_{J+1}, for example) will also fail to change the bottom line. This is simply the Modigliani-Miller logic applied to performance bonds.

Matters are quite different for a firm paying efficiency wages. Like a performance-bond firm, an efficiency-wage firm will want to shut down whenever profits are negative, and this is an unhappy state of affairs for workers. Here, however, there is potential for a "continuation game."

Suppose, for the sake of argument that in state $(J-1)$ the value of the firm is slightly negative. (Note that the value of J is greater than in the performance-bond example.) In $(J-1)$ the value of jobs is positive and possibly quite large. In state $(J-1)$ profits in the absence of an agency problem would approximately equal the large efficiency-wage premium times labor demand; this is what distorts the firm's exit choice. The distortion comes from the separation of control rights over exit from claims to the returns to continued operation. In principle, workers would be willing to offer the firm a side payment to keep the firm in operation, since, if A_J is less than the mean, there is a better-than-even chance that next period's state will be better. In essence, workers would be willing to buy call options on their jobs. If the state were $J-2$, the option would be more expensive, and have a lower expected return.

We have just described a theoretically *feasible* transaction. The exact nature of the *equilibrium* transaction would depend on the variety of factors affecting the bargaining strength of workers and employers and the bargaining environment. These factors include, at a minimum, the flexibility of monitoring arrangements, the nature of the underlying fundamentals (the likelihood of a firm come-back, for example), and the structure of information.

Explicit lump-sum payments are as likely to be troublesome here as they are for performance bonds. Consequently, side payments would need to be embedded in the compensation stream, just as Lazear embeds bonds in upward-sloping earnings profiles. Doing so complicates matters, however. If, for example, the side payments took the form of simple wage concessions, the wage path would violate the no-shirking constraints.

Workers and owners in a dying efficiency-wage firm thus face the following dilemma: On the one hand, resolution of the effort regulation problem requires that the value of jobs be maintained. On the other hand, the very actions the firm takes to keep jobs valuable—higher wages—only hasten the demise of the firm. There is potential for a mutually beneficial deal, but the new implicit contract must continue to be incentive-compatible.

4.3 Solving the Agency Problem in a Dying Firm

The previous section makes the case that firms and workers in an efficiency-wage firm have an incentive to construct mechanisms, however crude, that allow workers to make concessions while maintaining the incentive to provide effort. When such mechanisms can be found they will weaken, perhaps even reverse, the first-order prediction of our model—that compensation must rise as firms approach bankruptcy.

There is one obvious nonmonetary way for workers to make concessions in a dying firm: employee monitoring. In any efficiency-wage firm, employers will want to adopt practices that make worker monitoring more precise, since this serves to reduce the efficiency wage premium, as illustrated by Figure 4. Workers will generally resist such efforts because more effective monitoring reduces employee rents.

Workers' incentives are different, though, in a firm on the edge of bankruptcy. When the alternative is the loss of valuable jobs, workers *want* improved monitoring exactly because it would lower the wage; improved monitoring effects an incentive-compatible monetary concession. (Figure 4 also demonstrates this—increasing d lowers the exit threshold.) The change in monitoring can happen in one of two ways. First, employees may simply lower resistance to changes the employer wishes to make. They may make such concessions even if they are irreversible, reducing future as well as current wages; workers accept a capital loss on their jobs.

Second, workers may find it desirable to coordinate on higher-effort, in effect improving self-monitoring. Since this involves a difficult free-rider problem, it would need to be implemented through mechanisms such as changing group work norms or cooperation with management on institutions such as quality circles or other participatory work arrangements. Self-monitoring is likely to dissipate if the firm returns to health, since workers' incentives revert to normal.

As we mentioned in the previous section, simple wage concessions are not incentive-compatible. On the other hand, accepting lower compensation now in return for higher compensation later, contingent on recovery of the firm is incentive-compatible for the worker. The difficulty, of course, is that this scheme is not incentive-compatible for the firm, which has an incentive to renege when the firm is again healthy. The obvious solution is to give the worker contingent claims on the firm's future profits—equity or options. This transaction could take the extreme form of selling the firm to its employees at a price less than the collective value of their jobs.

Indeed, employee buyouts are a phenomenon often associated with firms in difficult circumstances. Since there are large transactions costs and at least partial transfer of control rights, they must serve some purpose beyond a mechanism to induce continued operation. We offer four conjectures. First, as the previous paragraph argues, buyouts may simply enforce promised repayment of current wage concessions. It is not clear, however, why a simple transfer of shares or options would not accomplish the same objective more cheaply.

Second, an equity stake combined with control rights would help to reinforce workers' efforts at group-monitoring by reducing the size of the free-rider problem.

Third, if workers' information about their ability to successfully self-monitor is better than the firm's, their willingness to accept an equity stake in exchange for wage concessions might be a credible signal that self-monitoring can reduce the agency problem, allowing wage concessions to be profit maximizing.

Fourth, Ben-Nur and Jun (1996) make a complementary argument, that management may have private information about the state of the firm.[16] Workers understand that firms always want give-backs, even in good states. The firm's willingness to sell equity to workers at a very low price serves as a credible signal that the firm is indeed in a bad state. Revealing a bad state actually raises the efficiency wage, however, so the net effect of management's offer to sell the firm is not clear.

5. Concluding Remarks

Employers' efforts to resolve agency problems often entail the use of various mechanisms that give workers' jobs positive value. Because the value of jobs is tied inextricably to job stability, there is an unavoidable link between compensation policies and uncertainty in a firm's environment. Our paper studies this link explicitly. Employment and exit are determined endogenously. We study efficiency-wage

[16] This is not the case in the symmetric information model we use in this paper.

and performance-bond compensation strategies encompassed by a general model.

The results of this exercise indicate: (1) Compensation levels depend systematically on characteristics of the firm and its environment, not solely on characteristics of the worker and the job. (2) The predicted cyclical properties of wages are altered by these links (relative to deterministic models). In particular, we find a countercyclical impulse to compensation. (3) Both variants of our theory predict high compensation when firm fundamentals are weak. In the efficiency-wage variant, distorted exit choices are a corollary.

In general terms, valuable-jobs models of compensation give economic content to the common public rhetoric about workers as "stakeholders" in firms. The implications of efficiency-wage and performance-bond models differ dramatically, however, when it comes to attempts to preserve these "stakes." In the frictionless Modigliani-Miller world, where performance bonding costlessly resolves agency problems, the fact that some of the firm's debt is held by workers has no meaningful effect on any facet of the firm's operation; liquidation of valuable jobs is always efficient. In contrast, in an efficiency-wage firm, the prospect of shutdown is likely to trigger a struggle to retain jobs that have positive value, even when the value of the firm to shareholders is zero. Although the mechanisms through which this struggle is played out in troubled real-world firms appear quite diverse, an attempt to integrate these mechanisms into an overall model of compensation seems likely to be an informative avenue of research.

In the several decades since Modigliani and Miller's original work (1958), economists have come to realize that understanding firms' financial decisions in a stochastic setting often depends on understanding sophisticated responses to the various market imperfections that firms sometimes encounter. A similar observation pertains to firms' employment practices. In a broad sense we regard this paper as a first step toward a full understanding of the implications of that observation.

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Figure 1
Baseline Efficiency-Wage Solution

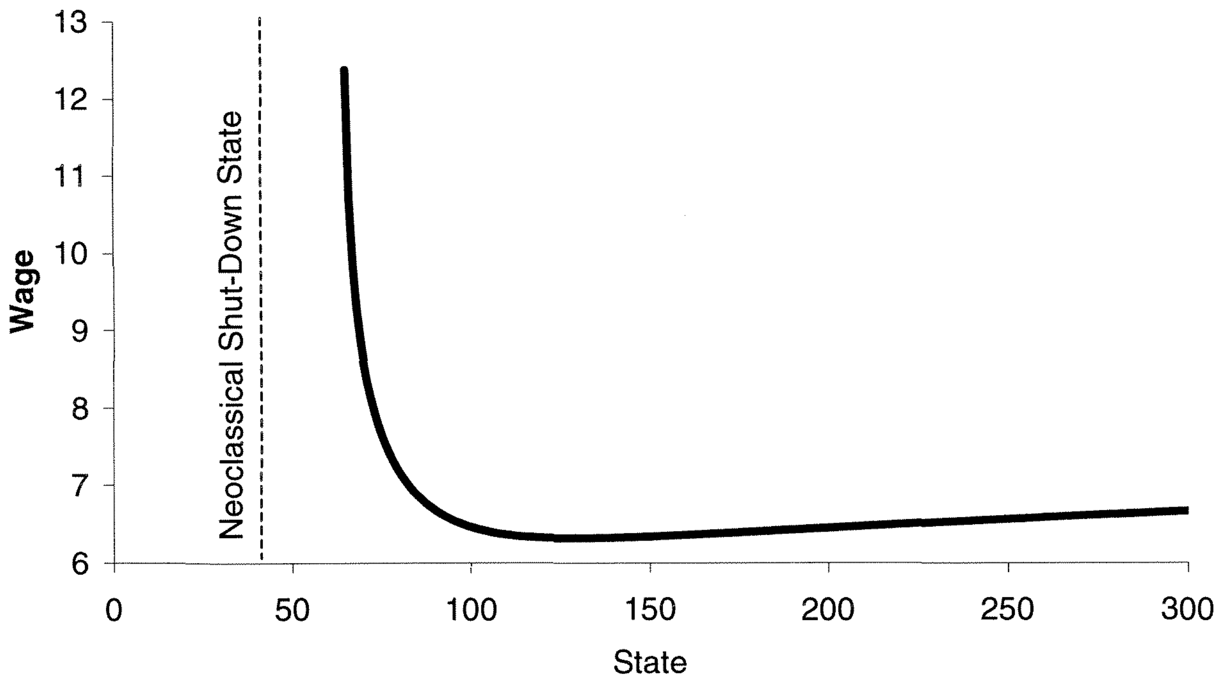

Figure 2

Changing ρ, Unconditional Variance Constant

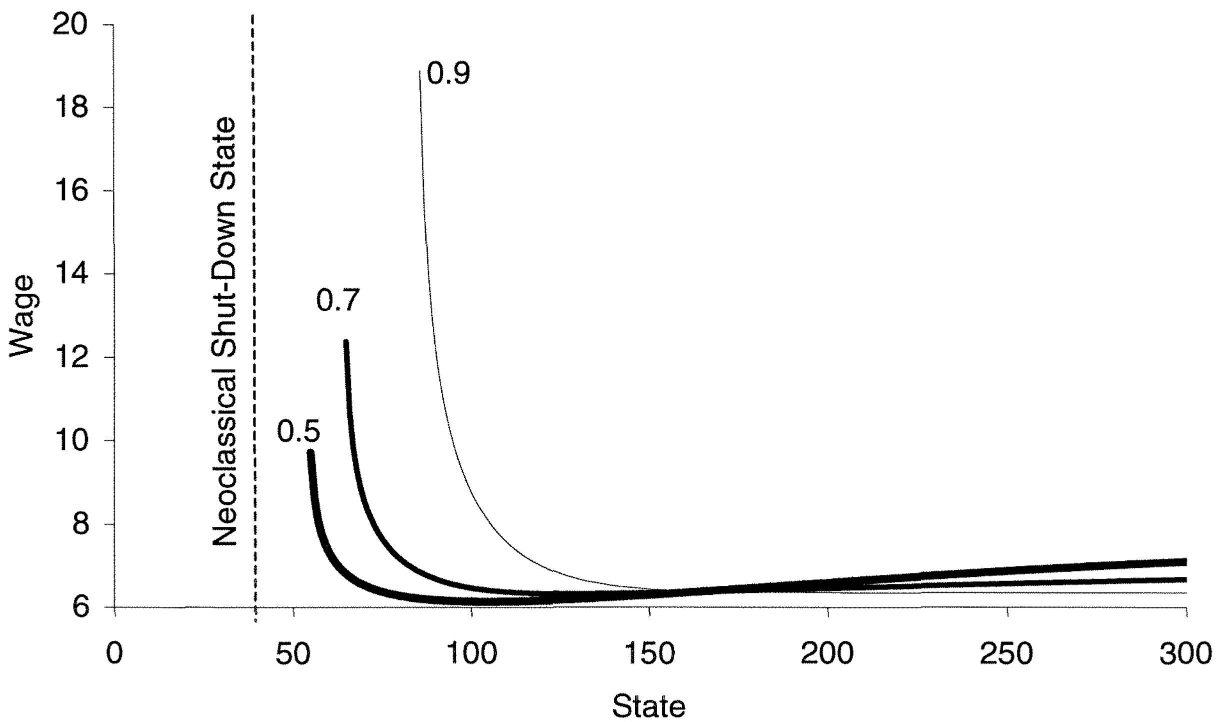

Figure 3
Changing Innovation Variance σ_ϵ

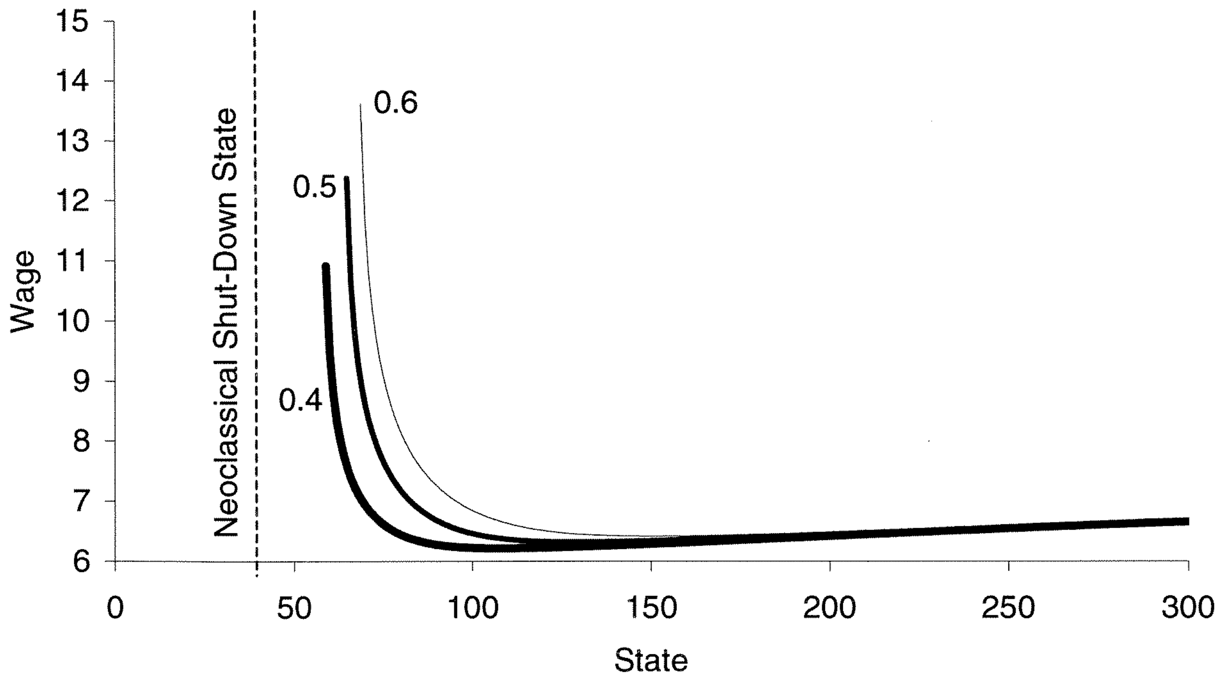

Figure 4

Changing Monitoring Probability, *d*

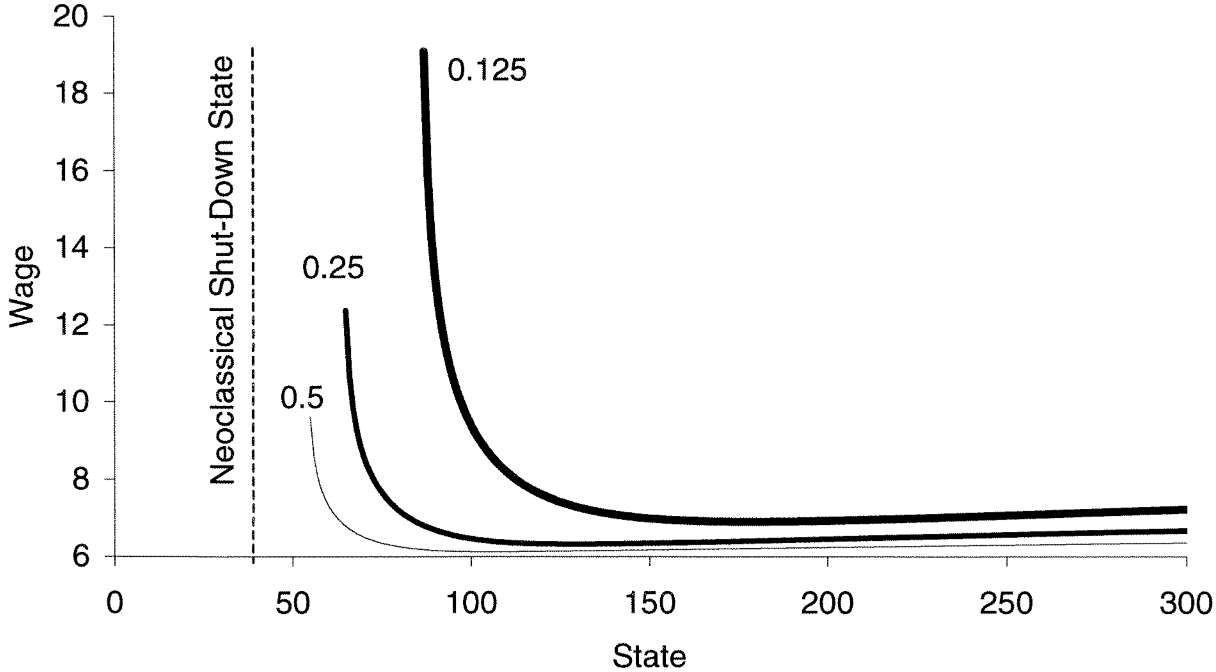

Figure 5

Required Rate of Return on Performance Bond