8 The Structure of Uncertainty and the Use of Nontransferable Pensions as a Mobility-Reduction Device

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8.1 Pensions as a Labor Compensation Instrument

Although pensions are an undeniably important component of most workers' compensation packages, whether or not their role is unique is more problematic. In terms of the structure of compensation, pensions have the following effects. By shifting compensation from one's working years to the period of retirement, they tilt the life-cycle earnings path upward. During the initial periods of employment, workers typically make contributions to the pension but acquire no earned rights to the benefits, thus effectively reducing their wage rate and imposing a transactions cost on job changes. As their experience increases, these contributions are coupled with at least partial earned benefit rights.

The extent to which market processes will lead to the use of nontransferable pension benefits is greater than might be concluded from current pension plan characteristics since the 1974 Employee Retirement Income Security Act (ERISA) imposes minimal vesting requirements. Before the advent of ERISA, the majority of workers (70% from 1950 to 1970) who left their jobs for voluntary or involuntary reasons forfeited their pension benefits (see U.S. Senate 1971).

ERISA now requires full pension vesting after 10 years of service, but for the high-turnover group of inexperienced workers a primary implication of pensions is that they impose a fixed cost on job changes. The ERISA requirements have led to "cliff vesting" for almost three-fourths of all workers covered by private pensions.[1] Under these provisions,

workers with fewer than 10 years of experience forfeit all pension benefits if they leave the firm. These fixed costs will reduce worker turnover, an effect that has strong empirical support.[2]

The economic rationale for this transactions cost component of compensation has been discussed in a number of contexts. The forfeitable portion of the pension benefits can be viewed as the worker's compensation to the employer for its training investment in the worker.[3] Such a role for pensions has been formalized for both models of external job search (Mortenson 1978) and models of on-the-job experimentation by workers and firms.[4] Pensions further reduce turnover costs in that they serve as a self-selection device by attracting more stable employees to the firm (Viscusi 1980). Finally, pensions can also induce efficient turnover in situations in which there is the potential for worker shirking.[5]

These constructive functions are by no means unique to pensions. Other forms of upward tilting in the temporal wage structure can produce similar effects. If, however, it is difficult to vary wages on a period-by-period basis, pensions can increase the flexibility of the compensation system. Firms may attempt to link wages on the job to job-specific experience to provide a sense of equity for all those working at the position. Pensions permit firms to make a link between wages and total periods worked at the firm, as well as to past job performance (as reflected in past wages). If there is an enterprise-specific component to worker productivity or the firm's hiring and training investment (or in stochastic models to the information workers possess), it will be desirable to have such wage flexibility.

Even apart from such wage structure rigidities, pensions may be a more attractive compensation mechanism for promoting the aforementioned labor market functions. In addition to their very favorable tax status, pensions can be distinguished from a simple wage payment in that they serve to promote savings for old age and insurance against postretirement declines in income. By avoiding problems of adverse selection through mandatory pension coverage, reducing the fixed costs associated with annuity purchases, and promoting forced savings,[6] pensions may offer advantages that individually purchased annuities do not offer. There is, however, a trade-off since provision for increased resources in one's postretirement years reduces one's preretirement income, which might also have served an insurance function to the extent that it promoted stability in the preretirement earnings path.

In this paper I will not be concerned with such factors that might give pensions a unique role to play, but rather I will address the role of pensions as a form of deferred compensation that is contingent on remaining at the firm. The transferable pension benefit rights do not affect mobility decisions and will not be the focus of my analysis.

The two mobility-related functions of pensions to be considered are interrelated. First, the deferred compensation structure of pensions will re-

duce labor turnover by leading more stable employees to self-select into the firm. Second, once at the firm, workers' incentive to switch employers will be reduced by the transactions cost aspect of pension benefits.

This reduced mobility represents a beneficial labor market function from the standpoint of hiring and training costs, but if a worker is trapped in a job he would like to leave the implications may be quite different, particularly if he did not have accurate perceptions of all of the uncertainties he faced. These effects are reminiscent of the types of concerns that led to the passage of ERISA. The principal issue to be considered here is whether this immobility is optimal and, if so, when.

Uncertainty plays a critical role in this analysis, both in terms of providing workers an incentive to change jobs and through its effect on the welfare implications of nontransferable pensions. Because of the long lags before individuals acquire full benefit rights, the nature of the uncertainties may be quite different from that in the standard one-period compensating wage differential model in which workers encounter a single lottery. Learning is likely to play an important role, as will the possibility that individuals may face a sequence of interrelated risks over time.

Section 8.2 of the paper begins with a relatively conventional compensating differential model, and sections 8.3 and 8.4 consider learning and other structures of uncertainty. Although pensions have no essential role to play in a single-period lottery model, once the uncertainty assumes a dynamic character they do serve an important mobility-reducing function.

8.2   The Optimal Wage Structure under Uncertainty: The Standard Case

The most prevalent uncertainty assumption, which is the foundation of the classic compensating differential analysis, is that the worker faces lotteries that are independent and identically distributed over time. In the case of job risks, there is assumed to be an invariant stochastic process governing the chance that a worker will be injured. If the worker has a reservation wage w_0 and the prospective alternative job poses a chance p of suffering a loss $-\theta$ in each period and a probability $1 - p$ of no loss, to attract the worker to this uncertain job the employer must offer a wage w_1 equal to $w_0 + p\theta$ in each period.[7] This wage will not only attract the worker initially, it will always keep him at the firm if there are no time-related changes in his employment choice problem.

Instead of offering a uniform wage rate, the firm could offer wages on a period-by-period basis. Any upward tilting of the wage structure that offers the same present value as the compensating differential wage package will suffice. Downward tilting with the same present value will attract the worker initially but will not retain him once the expected net wage (includ-

ing the loss $p\theta$ in each period) drops below w_0. The firm will not only incur mobility-related costs in this instance, its wage bill per period of employment will rise as well.

One form of upward tilting in the wage structure is the use of pensions. I will treat pensions as giving the worker a payment of z during his final year of employment, where z represents the discounted present value of his annuity. To the extent workers acquire at least a partial earned right to pensions during the earlier part of their careers, some of this value may be spread over a larger number of periods.

Although making the number of periods to the worker's choice problem arbitrarily large poses no conceptual problem, it is simplest to focus on the two-period case.[8] The worker selects his job based on its expected present value. Let r denote the worker's discount rate, which is the inverse of one plus the interest rate. The implicit assumption is that workers are free to borrow and lend at this rate. Workers would, for example, be indifferent to receiving their entire lifetime income through a pension or having this income spread more evenly over their lifetime. A principal reason we do not observe extreme outcomes such as this is that individuals' discretion over their work effort creates an adverse incentives problem when making loans based on anticipated lifetime income.

Any acceptable wage package consisting of a base wage w and a pension z must compensate the worker for the loss θ in each period and for the opportunity cost w_0 of employment, so that the compensation package must satisfy

$$(1) \qquad (w_0 + p\theta) \sum_{i=0}^{1} \beta^i = w (\sum_{i=0}^{1} \beta^i) + \beta z.$$

Any positive value of z will lead to tilting in the wage structure, as compared with the flat wage case. The maximum tilting occurs when the worker takes all of his wage in the form of pension payments or he sets w equal to zero.

A final possible wage structure is ex post compensation for the adverse job outcome. The firm can attract workers by offering a base wage w_0 and paying an additional premium of θ to each worker who suffers an adverse outcome. This approach will have the same cost to the employer as the pension and flat wage. The informational requirements for ex post compensation are, however, much greater since the firm must be able to monitor the adverse outcome. Although this task is not difficult for readily visible job injuries, for other job attributes such as those relating to job satisfaction it is not as straightforward. If a worker will be paid a bonus if he dislikes a co-worker or if he finds his job strenuous or boring, there will be an obvious incentive to misrepresent the job's attractiveness.[9]

The principal advantage of ex post compensation is that it eliminates any variance in the worker's net rewards in each period, which will always

be w_0. This stabilization both across and within periods irrespective of the lottery outcome will be attractive if workers are risk averse. Under a flat wage policy there will be a possible within-period wage gap of θ. The pension package leads to a comparable within-period spread but a lower base wage. If the insurance value of the pension is not taken into account, so that z is treated as comparable to a bonus in the final period of work, risk-averse workers will value pay packages with pensions less than a flat wage, with ex post compensation valued highest.

8.2.1   Heterogeneous Workers

There will also be differences in the attractiveness of the wage structure arising from variations in individuals' probability assessments.[10] Suppose that a fraction f of the potential work force assesses the probability of incurring a loss θ in each period as $\hat{p}$, while a fraction $1 - f$ assess this probability as p, where $\hat{p} < p$. This heterogeneity will lead the wage structures to have different relative costs and different welfare implications, depending on the source of the heterogeneity.

Consider first the situation in which these probability assessments derive from actual differences in the lotteries. Some workers may be more accident prone or more likely to be productive. The wage costs to the employer will be least if the employer can design the wage structure to screen out the high-risk workers and to attract only low-risk workers. With a uniform wage over time of $w_0 + \hat{p}\theta$, the flat wage structure will serve as a perfect self-selection device as workers with assessed failure probabilities p will not find the job attractive. Pensions serve an identical self-selection function and will impose the same discounted expected cost, where the form of the pension continues to satisfy equation (1) (after replacing p by $\hat{p}$). Ex post compensation will not screen out any high-risk workers, as the per period wage bill per worker will be $w_0 + f\hat{p} + (1 - f)p$. Workers will be allocated inefficiently, and the firm's wage bill will be higher than for the other wage structures.

If the differences in probability assessment arise from misassessments of the risk, the relative costs to the employer remain the same, but the efficiency implications are altered. For concreteness, suppose that p is the true probability of failure for all workers but that a fraction f underestimate this p to be $\hat{p}$. The value of p will be assumed to be constant over time, or there is assumed to be no learning. For workers who misassess the risk, the actual expected utility of the uncertain job under either the flat wage or pensions will be $[w_0 + (\hat{p} - p)\theta] \sum_{i=0}^{1} \beta^i$, which is below the value of the alternative job; individuals who correctly assess the probability will be screened out. Ex post compensation prevents any such welfare losses and will attract a broad mix of workers. The wage costs will, however, be high-

er (i.e., $w_0 + p\theta$ per period, as before) so that there is no incentive for employers to utilize this wage mechanism.

If all workers systematically overestimate the risk, employers can limit their wage costs to $w_0 + p\theta$ by offering ex post compensation. Through judicious choice of the wage structure, the employer can always limit the per period employment costs to $w_0 + p\theta$. If some workers have a lower risk assessment, the wage costs can be lowered further through a self-selecting wage mechanism. Biased assessments consequently can never hurt the employer, but they can enable him to make money from systematic underassessments of the risk.

Under a situation of time-invariant lotteries, pensions have no essential role to play. Flat wages, pensions, and all intermediate forms of wage structure tilting impose the same wage costs, provide workers with the same level of welfare, and have the same self-selection properties. (There are, however, some differences for risk-averse workers involving a trade-off between expected utility before and after retirement if money is not transferable across periods on an actuarially fair basis.) Ex post compensation protects misinformed workers from welfare losses but sacrifices the self-selection properties of the other wage structures. Moreover, it is never in the employer's financial interest to utilize this mechanism when there is any heterogeneity in risk perceptions except in the bias case in which all workers overestimate the risk.

8.3   Lotteries with Worker Learning

8.3.1   Problem Structure

A variant on the standard lottery structure is to introduce the potential for worker learning. When workers do not possess perfect information regarding the job lotteries they face, it will be desirable to revise these perceptions as additional information is acquired. In the earlier misperception discussion, for example, it was perhaps unrealistic to assume that workers who underestimate the job risks would never revise these judgments in the face of repeated lottery outcomes. In the case of income uncertainties, there are a variety of sources of information that can be used to form these judgments. The ease of the job, the performance of one's co-workers, the reactions of the boss, and one's current productivity can all contribute to these assessments. Uncertainty regarding nonmonetary rewards can be treated similarly.

For concreteness, I will continue to assume that a loss of θ is generated by an underlying stochastic process that is independent and identically distributed over time. The difference is that the worker does not know the value of the probability p in these Bernoulli trials. I will assume that he

has a prior assessment p of the chance of an adverse outcome but that he updates this prior in Bayesian fashion based on his on-the-job experiences. I will denote by q the true probability that θ will prevail, which is assumed to be known to the employer. I will often assume that the prior be characterized by a beta distribution, so that the posterior probability $p/p(m, n)$ of θ after observing m unsuccessful outcomes and n successful outcomes is

$$p(m, n) = \frac{\gamma p + m}{\gamma + m + n},$$

where γ represents the precision of the prior.

To investigate the role of pensions, it is instructive to focus on the two-period case.[11] The principal implications of the model will hinge on whether or not there is any chance that the worker may find it desirable to leave his job, which are principles with broad applicability. Two situations may occur. Either the worker chooses to leave the uncertain job after an unsuccessful outcome or he remains with it. A third possibility, that the worker may depart after a successful job experience, can be ruled out if the life-cycle wage structure is not downward sloping.[12]

The choice for the firm will be whether or not it chooses to retain the worker following an unfavorable outcome. Let W_a represent the per period wage costs if the worker is always induced to remain with the firm, and let W_b represent the per period wage costs if the worker leaves after an unsuccessful outcome. For the wage structures considered below, $W_a > W_b$, or it is always more expensive to retain the worker irrespective of the job outcome. Let h represent the hiring and training costs per worker.

In a two-period model, the discounted period of employment is $1 + \beta$ if the worker never leaves the job and $1 + \beta(1 - q)$ if there is a chance q of an unfavorable first-period outcome that will lead him to quit. It will be desirable to keep the worker irrespective of the job outcome if the per period employment costs are lower, or

$$\frac{h}{1 + \beta} + W_a < \frac{h}{1 + \beta(1 - q)} + W_b,$$

which reduces to the requirement

(2) $\qquad h > \dfrac{[1 + \beta(1 - q)](1 + \beta)}{\beta q} (W_a - W_b) > 0.$

If the turnover costs are sufficiently large, it will be desirable to always keep the worker. Rather than analyze the implications of turnover costs for each wage structure, I will focus on the wage mechanisms that yield the lowest values of W_a and W_b. One could then employ equation (2) to ascertain if it is worthwhile to prevent turnover.

8.3.2   Wage Structures That Prevent Turnover

To ensure that workers never leave the uncertain job, the wage in period 2 must be sufficiently large to retain them after an adverse job experience in period 1. Since the worker's maximum expected loss in period 2 will be $p(1, 0)\theta$, the flat wage will have an associated discounted cost C_f equal to $C_f = [w_0 + p(1, 0)\theta](1 + \beta)$. Unlike the results for time-invariant lotteries, the flat wage clearly can never be optimal from the firm's standpoint since workers are being overpaid in period 1 when their expected loss is $p\theta$. Since no flat wage below $w_0 + p(1, 0)\theta$ can retain workers in period 2, this wage structure is necessarily dominated by other, more flexible alternatives.

Ex post compensation will cost the employer $w_0 + q\theta$ in each period, where q is the employer's assessed probability of an adverse outcome. If the employer and worker assessments are identical and q equals p, the discounted cost C_x of this form of compensation will be $C_x = (w_0 + q\theta)(1 + \beta) = (w_0 + p\theta)(1 + \beta)$. It is noteworthy that C_x is independent of all characteristics of the worker's probability assessments except the value of his prior probability of an adverse outcome. The precision does not enter. This property is true more generally in situations possessing this two-armed bandit structure whenever there is no chance of leaving the uncertain job.

The final alternative is to vary wages on a period-by-period basis or, equivalently, to offer the worker a pension z in the second period if he remains with the job. The minimal tilting of the wage structure that will always keep the worker on the job occurs when

$$(3) \qquad\qquad w + z - p(1, 0)\theta = w_0,$$

or

$$z = w_0 - w + p(1, 0)\theta.$$

One must then ascertain the minimal base wage, which will satisfy the following condition:

$$w - p\theta + \beta p[w + z - \mathrm{p}(1, 0)\theta]$$
$$+ \beta(1 - p)[w_0 + z - p(0, 1)\theta] = w_0 + \beta w_0,$$

or

$$(4) \qquad \begin{aligned} w + \beta(w + z) &= w_0(1 + \beta) + p\theta + \beta p[p(1, 0)\theta] \\ &+ \beta(1 - p)p(0,1)\theta = (w_0 + p\theta)(1 + \beta). \end{aligned}$$

The expression on the left-hand side of equation (4) is the discounted wage cost C_p to the firm of the pension, which is equal to C_x above. Imposing the requirement in equation (3) on $w + z$, one can calculate the wage structure components, which are

(5)
$$w = w_0 + p\theta + \beta[p - p(1, 0)]\theta$$

and

(6)
$$z = (1 + \beta)[p(1, 0) - p]\theta > 0.$$

The value of z represents the minimal upward tilting of the wage structure that will induce the worker to remain on the job. The minimal tilting required decreases with the precision of the prior since $\delta p(1, 0)/\delta \gamma < 0$.

Alternatively, since the firm can always postpone wage payment arbitrarily so long as the discounted value to the worker is unchanged, it can give the worker all of his compensation in terms of a pension. I will denote this upper limit on pension payments that impose the same cost as the wage structure in equation (4) by $\bar{z}$, where

(7)
$$\beta\bar{z} = (1 + \beta)(w_0 + p\theta) = C_p.$$

The discounted pension is simply the present value of the minimal wage structure cost under uncertainty. The value of C_p equals C_x for ex post compensation so that pensions and ex post compensation are the cheapest turnover-reduction mechanisms. If there are costs to monitoring the outcome of the job lottery, wage structure tilting will be dominant.

8.3.3   Heterogeneous Perceptions

If there is heterogeneity in workers' risk perceptions, wage structure tilting will be the least costly alternative except in one instance. If all workers have biased assessments and overestimate the risk, the firm can limit its wage costs to C_x by offering ex post compensation. This form of wage structure can never induce worker self-selection.

Pensions will, however, induce self-selection. Assuming that they are set so as to prevent worker turnover, the only relevant parameter of the prior distribution is its mean. Workers with lower mean values of the prior will be self-selected, and the cost of the firm's wage structure will be given by equation (4), where p corresponds to the assessed initial risk for the low-risk group. Although for this group there will be no turnover, there is no assurance that all turnover will be eliminated. Some workers with higher values of p but with very imprecise initial judgments may be attracted to the job and may then quit if the first-period outcome is unsuccessful.

Consider two groups of workers, which I will designate type 1 and type 2, where the respective prior probabilities of an adverse outcome are p_1 and p_2, where $p_1 < p_2$. For prior probability assessments from the beta family, if the precision $\gamma_1 \leq \gamma_2$, even pensions with minimal tilting (eqs. [5] and [6]) will screen out higher-risk group 2 workers. If however, $\gamma_2 < \gamma_1$, it may be that the group with the higher probability p_i of an adverse outcome may find it desirable to start the job, quit after an unfavorable outcome, and collect the pension with a favorable outcome.

To show that this is the case, it suffices to construct a numerical example. Let $\gamma_1 = 100$ and $p = .5$, and substitute these values into equations (5) and (6), yielding terms I will designate w_α and z_α. Worker 2 has beliefs characterized by $\gamma_2 = 1$ and $p_2 = .51$. Let the discount factor β be one. Whereas a $w + z$ value equal to $w_0 + .51\theta$ is sufficient to prevent turnover of worker 1 in period 2 after an adverse outcome, this value must be at least $w_0 + .75\theta$ to prevent worker 2 from quitting since his looser prior is updated more after the adverse initial job experience. Below I will assume that the pension tilting is set at the minimal level needed to retain worker 1, which in turn will lead worker 2 to quit after an unfavorable period 1 outcome.

Worker 2 will, however, find the job attractive in the initial period if

$$w_\alpha - p_2\theta + p_2 w_0 + (1 - p_2)[w_\alpha + z_\alpha - p_2(0, 1)\theta] > 2w_0.$$

Since the terms on the left-hand side of the equation simplify to $2w_0 + .1\theta$, he will accept the uncertain job and will not be screened out.

Pensions $\bar{z}$ that involve maximum upward tilting (i.e., all wages are paid in period 2) are more likely to serve as a complete self-selection device since any worker who leaves after an adverse outcome will have a chance $1 - p_2$ of receiving no wage payment. Moreover, concentrating the entire wage in the second period makes it more likely that the worker will stay in period 2 following an adverse outcome, in which case only the mean p_i of the prior is relevant.

Letting $\bar{z}$ denote the maximum wage structure tilting package that is required to attract and retain the low-risk type 1 worker, we have the result that the type 2 worker will remain on the job after an adverse outcome if $\bar{z} - p_2(1, 0)\theta \geq w_0$, or, on substitution for z from equation (7) and rearranging terms, $w_0 \geq \theta[\beta p_2(1, 0) - p_1]$. The maximum pension always prevents turnover if w_0 exceeds the terms on the right-hand side of this inequality. Unless $p_2(1, 0)$ exceeds p_1, and either this gap is very large or θ is sufficiently large, pensions can always prevent turnover. Once this condition is met, the type 2 worker will necessarily be screened out since the attractiveness of a wage structure involving no turnover hinges solely on the initial risk assessment, and $p_2 > p_1$. Although pensions do not always act as perfect self-selection devices, increasing the upward tilt of the wage structure enhances their effectiveness as a self-selection mechanism.

When there are legitimate differences in worker riskiness, this risk-selection property is attractive because it reduces wage costs by matching low-risk workers to the job. With biased perceptions, there will be cost savings for the firm but less favorable implications for worker welfare. As in section 8.2, the cost of ex post compensation will be based on the average riskiness of workers attracted and will be more expensive than wage structures for a self-selected, low-risk group.

8.3.4   Wage Structures That Permit Turnover

If the wage structure permits worker turnover to occur, the choice is narrowed to flat wages and period-by-period wage payments. Ex post compensation never enters since any time- invariant compensation system of this type will necessarily prevent turnover in both periods unless the employer fires all workers with adverse initial job experiences.

Unlike the case in which the wage structure must always prevent turnover, the flat wage structure will be successful in attracting workers and keeping them following a success but not after a failure in the first period. Since workers with favorable job experiences update their priors to $p(0, 1)$ $< p$, any flat wage that attracts the worker to the firm initially will overpay him in later periods.

The minimal flat wage w_f that will attract the worker to the firm must meet the condition that

$$w_f - p\theta + \beta p w_0 + \beta(1 - p)[w_f - p(0, 1)\theta] = w_0 + \beta w_0,$$

or, solving for w_f,

$$w_f = w_0 + \theta \frac{[p + \beta(1 - p)p(0, 1)]}{1 + \beta(1 - p)} < w_0 + p\theta,$$

since $p(0, 1) < p$. With learning, the firm lowers its wage costs per period worked by only retaining those workers with favorable experiences. One can also show that $\delta w_f / \delta \gamma > 0$, or the value of this wage increases with the precision of the prior.

The pension option must meet three requirements. First, the pension must not retain the worker in period 2 after an adverse outcome, or $w + z - p(1, 0)\theta < w_0$; otherwise the wage structure reduces to a situation treated in section 8.3.2. Second, the wage structure must retain the worker following a favorable outcome, or $w + z - p(0, 1) \geq w_0$. And, finally, the worker must accept the job initially, or

$$w - p\theta + \beta p w_0 + \beta(1 - p)[w + z - p(0, 1)] = w_0 + \beta w_0.$$

The minimal pension z can be negative since it is easier to retain the worker after a success than to attract him initially.

A fundamental concern is how individuals' probability assessments relate to the properties of the wage structure. In particular, for what combinations of precision γ and initial risk assessments p will the worker never start the job, accept the job and quit after an adverse experience, or never leave the position? I will present these requirements for pensions which, depending on the degree of tilting, will include all possible temporal wage structures.

The requirement that the worker just be indifferent between remaining on the job after an adverse outcome or quitting can be written as

$$G = w + z - p(1, 0)\theta - w_0 = 0.$$

The combination of acceptable (γ, p) values that satisfy this requirement is positively related since

$$\frac{\partial \gamma}{\partial p} = \frac{-G_p}{G_\gamma} = \frac{-\gamma(\gamma + 1)^2}{p - 1} > 0,$$

or the highest γ value that is acceptable is positively related to the initial risk p. Similarly, the worker will be indifferent to starting the job initially if

$$H = w - p\theta + \beta p w_0 + \beta(1 - p)[w + z - \frac{\gamma p\theta]}{\gamma + 1} - w_0 - \beta w_0 = 0,$$

where one can show that

$$\frac{\partial \gamma}{\partial p} = \frac{-H_p}{H_\gamma} < 0.$$

As the assessed initial risk rises, the worker requires that his prior be less precise if he is to accept the job initially.

Figure 8.1 sketches the three possibilities.[12] For very high risks, the worker never starts the job. Tighter probabilities lower the value of the highest acceptable initial risk since the worker updates tight priors less, thus reducing the potential value of the job after a success. The precision of the prior has the opposite effect for preventing workers from ever leaving. Higher values of p will be accepted for tighter priors since these priors
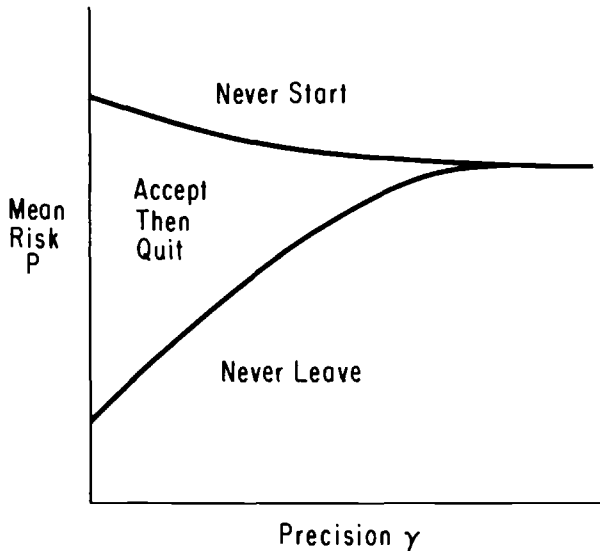

Fig. 8.1   Turnover decisions and prior beliefs.

are not updated as much after an adverse outcome, making it easier to retain the worker. In the intermediate (γ, p) range, the worker accepts the job initially and quits after an adverse outcome. The probability range satisfying this condition is greatest for low values of γ. In the limiting case, as $\gamma \rightarrow \infty$, this middle range disappears; the worker simply has a cutoff probability above which he will not start the job and below which he will never leave it.

This diagram can also be applied to the issue of self-selection. Although pensions that attract workers but do not keep them may screen out some high-risk workers, pensions will not always serve as a perfect self-selection device. As the top curve in figure 8.1 suggests, workers with higher assessed risks may find the job acceptable if the precision γ of their priors is sufficiently low. For workers with very high values of p, however, tilting the wage structure will screen them out.

The role of the precision of workers' priors is closely related to that of the variability of the risk, although the implications are quite different. If a worker were in a job situation that he would never leave, the only matter of consequence would be the mean risk. It would not matter, for example, if he faced a chance .5 of an adverse outcome or an equal probability that the underlying lottery poses a risk .4 or a risk .6. Even though he risks incurring an unfavorable lottery with p equal to .4 for every period of his work career, so long as there is no worker turnover the situations are identical.

For situations involving turnover, the variability is of substantial consequence. Workers prefer loose priors because they create possible employment paths on which they can quit if the information is unfavorable and remain if the information is favorable. Since the compensation package makes the worker indifferent between the uncertain job and alternative employment, variations in p have no effect overall on expected utility. A related issue that does have nontrivial implications is whether *for a given compensation structure and for particular employment paths,* variability in p raises or lowers the worker's expected utility.

The worker's expected utility in a situation where he finds the job acceptable but quits after an adverse outcome is given by

$$EU = w - p\theta + \beta p w_0 + \beta(1 - p)[w + z - \frac{\gamma p}{\gamma + 1}\theta].$$

Raising the assessed risk lowers worker welfare, as expected, since

$$\frac{\partial EU}{\partial p} = -\theta - \beta[w + z - \frac{\gamma p}{\gamma + 1}\theta - w_0] - \beta(1 - p)\frac{\gamma}{\gamma + 1}\theta < 0,$$

with the loss in utility decreasing in p, or

$$\frac{\partial^2 EU}{\partial p^2} = 2\frac{\beta\gamma\theta}{\gamma + 1} > 0.$$

These results imply that the worker's expected utility for this employ-
ment path is convex in p and takes the form sketched in figure 8.2. The EU
curve lies below the dotted line representing linear combinations of the ex-
pected utility when there is no chance of an accident (the vertical inter-
cept) and the expected utility when an accident is certain. From Jensen's
inequality we have the result that the worker would prefer a lottery on the
extreme certainty situations (with a chance p of the unfavorable outcome)
to a situation in which he faces the same lottery in each period with the
risk p of an adverse outcome.

It would be preferable from the worker's point of view to have an equal
chance of facing a risk .4 or .6 for both periods, as opposed to a lottery
with a risk of .5. The attractiveness of this lottery on extremes increases as
one increases the probability spread, where the highest-ranking situation
is that in which there is a 50:50 chance of suffering a loss or being free of
this loss throughout the employment path. For given employment paths
and wage structures, workers prefer greater risk in the sense of a mean
preserving spread on the job lottery probabilities.[13] The preferability of
such a lottery on extreme certain situations parallels the earlier result in
which workers display a preference for uncertain situations (i.e., low γ
values, since as $\gamma \to 0$ the mass of the probability density functions is con-
centrated around the values zero and one).

For the situation in which turnover may occur, it is instructive to ascer-
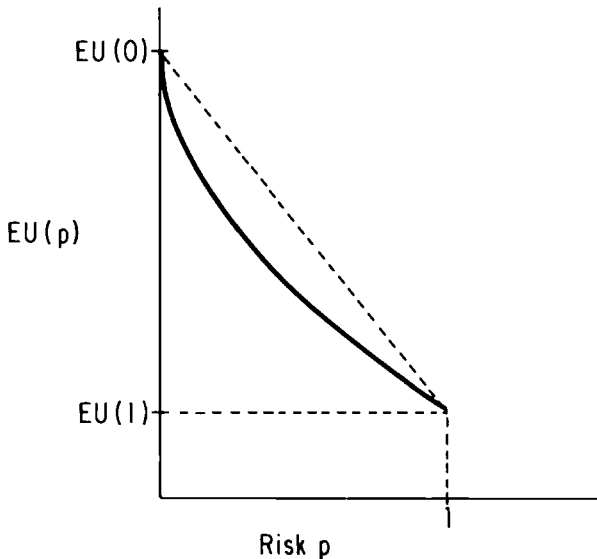tain whether the employer will be indifferent to the degree of wage struc-

Fig. 8.2   The convex shape of expected utility.

ture tilting. The range of $w + z$ values consistent with keeping the worker in period 2 only after a success must satisfy

(8) $$w + z - p(1, 0)\theta < w_0 \leq w + z - p(0, 1)\theta.$$

For concreteness, let

(9) $$w + z = w_0 + p(0, 1)\theta + s,$$

where the parameter s will be successively increased to assess the desirability of affecting the steepness of the earnings profile through greater reliance on pensions. The base period wage w required to attract the worker will be

(10) $$w = w_0 + p\theta - \beta(1 - p)s.$$

Suppose the firm's assessment of the risk of an adverse outcome is q. With this wage structure, it estimates that the discounted expected wage costs over the employment path C_p will be

$$C_p = w + \beta(1 - q)[w_0 + p(0, 1)\theta + s],$$

which on substitution for w simplifies to

$$C_p = w_0 + p\theta + \beta(1 - q)[w_0 + p(0, 1)\theta] + \beta(p - q)s.$$

The fundamental concern is how the firm's costs are affected by the degree of tilting. If workers overestimate the risk (i.e., $p > q$), C_p is minimized by setting s equal to zero; the earnings profile will be downward sloping or the pension z is negative. Moreover, if the degree of overestimation is sufficiently great, the employer can limit the per period wage costs to $w_0 + q\theta$ by offering ex post compensation. If p equals q, the firm is indifferent to the degree of tilting in the experience-earnings profile. Finally, if workers underassess the risk, the firm will set the value of s at its maximum value consistent with the requirements of equations (9) and (10), thus placing great reliance on pensions as a compensation investment.

The role of pensions in the presence of misperceptions is consequently to enable employers to reduce their wage costs by exploiting underestimates of the risk. Since workers with low values of p (and low γ) will tend to be self-selected into the job, there will be a tendency to attract such workers to the job. If workers underassess the risk and $p < q$, the optimal second-period wage for the case permitting turnover will be $w_0 + p(1, 0)\theta - \epsilon$, where ϵ is some arbitrarily small amount.

The issue then becomes whether the employer should raise the second-period wage by ϵ and prevent turnover altogether. This will generally not be the case since one can show that the condition that per period wage costs are lower with turnover,

$$\frac{w + \beta q(w + z - \epsilon)}{1 + \beta q} < \frac{w + \beta(w + z)}{1 + \beta},$$

reduces to the requirement $q \leq 1$. In the presence of pensions and misperceptions, the per period wage bill is always reduced by attracting workers who underestimate the risk and then permitting them to leave.

In effect, the firm is engaging in an unfair bet against the worker. The worker is shifting resources from period 1 to period 2 in the hopes that he will have a favorable job outcome and collect the pension. The firm makes money from these bets because workers do not collect the pension with as high a probability as they assessed; or, viewed somewhat differently, they shift their earnings forward in time on an actuarially unfair basis.

8.3.5   Streaks, Misperceptions, and Worker Welfare

If the worker is engaged not in a two-period problem but in a multiperiod problem, the difficulties caused by misperceptions will be enhanced. In the extreme case, the worker must have a string of n favorable outcomes in n periods in order to collect his pension (e.g., the risk of death). In this situation, the discounted expected pension benefit is $\beta^{n-1} z E(1 - p)^n$. Since biases in the assessed risk have a multiplicative effect, there may be severe losses in worker welfare and, as before, there will be an incentive for the employer to exploit these biases.

This outcome is of policy concern for several reasons. First, workers are gambling with resources for a heavily subsidized portion of their life cycle. If the pension system is not effective, the burden on publicly funded programs will be increased. Second, workers may be matched inefficiently to jobs. Third, ex post, workers will be unhappy with the outcome. This dissatisfaction by itself is not compelling since workers will always be unhappy after an unfavorable lottery outcome unless there is full contingent compensation. What distinguishes this situation is that ex ante the lottery might not have been attractive based on the true risks.

Finally, employers' discretion over the wage structure enables them to exploit these misperceptions. If ex post compensation is feasible, any losses arising from all workers systematically overestimating the risk can be prevented. If at least some workers underestimate the risk, any such losses can be prevented (irrespective of γ) by designing a self-selecting wage structure to exploit the misperceptions.

8.4   Alternative Lottery Structures

Even with the introduction of worker learning, the format in which individuals face uncertainties generated by a Bernoulli process does not reflect the nature of all job lotteries. For example, an individual may discover whether or not he will be successful in a particular line of work during the initial period. If he incurs an initial lottery on θ and will suffer whatever loss (possibly zero) he experiences in the first period throughout his work career, this situation can be handled in the two-period case using

the model in section 8.3 once we let $\gamma \to 0$. If, however, there is no such initial loss but the worker learns about his future prospects, the structure of the model is somewhat different. This situation is the focus of section 8.4.2.

Some outcomes, such as the arrival of an outside job offer or the chance of promotion, may occur with some probability p in each period, but once they have occurred they affect the rewards structure in all subsequent periods. A variation on this structure allows for the possibility that the size of the reward may vary as, for example, the attractiveness of the job may continually deteriorate or the worker may be promoted to increasingly higher positions. These situations will be addressed in sections 8.4.2 and 8.4.3.

Although this group of lottery structures is not exhaustive, it does span a rather broad spectrum of labor market possibilities. A principal purpose of this comprehensive coverage is to ascertain whether the desirability of upward-tilting wage structures, such as those induced by pensions, is a specific characteristic of situations with learning or whether, to take the opposite extreme, the optimality of flat wages pertains only to a very special type of uncertainty.

8.4.1   A Single Lottery

Suppose that the worker faces a single lottery in the initial period that will affect his rewards at the firm in all subsequent periods. He may discover whether or not he will like a particular line of work or be successful at it. There is some probability p that he will suffer a loss $-\theta$ in all subsequent periods and a chance $1 - p$ of no such loss. The lottery does not affect rewards in the initial period. To distinguish the payoff structure of pensions from that of ex post compensation, I will assume that there are three periods to the choice problem.

If the firm wished to retain only the low-cost workers with favorable experiences, the solution would be simple; it would simply offer a flat wage w_0. To give other wage structures a possible role, I will assume that turnover costs are sufficiently high that the firm wishes to keep workers with unfavorable experiences as well. It will, however, wish to hold down its wage costs by attracting workers with a lower risk p, a point I will return to below when heterogeneity is introduced.

The firm can offer a flat wage $w_0 + \theta$, with a present value C_f of

$$C_f = (w_0 + \theta) \sum_{i=0}^{2} \beta^i,$$

but it is clearly not in the firm's interest to do so. The worker experiences no loss in the initial period and is consequently overpaid by θ. In periods 2 and 3 there is a chance $1 - p$ that he will be overpaid by θ under this wage structure.

Ex post compensation, if feasible, can reduce these wage costs to

$$C_x = (\beta + \beta^2)p\theta + w_0 \sum_{i=0}^{2} \beta^i.$$

Workers' expected and realized utility is always w_0 in each period, just matching the value of the alternative job.

With accurate worker perceptions, pensions clearly cannot offer any improvement on this outcome, but they can offer firms the same wage costs without the requirement to monitor the lottery outcome. There is considerable leeway in the degree to which wages can be shifted forward in time, on an actuarially fair basis, into a pension. In the extreme case, all wages received could be in terms of a pension. The minimal value of the pension z plus the base wage must be high enough to retain workers who have had unfavorable experiences.

Rather than pursue all possible wage structures in which the wage can vary for each of the three periods, I will focus on the case where the firm pays a base wage w in all periods and augments this wage with a pension z in period 3. The present value of the wage package C_p is given by

$$(11) \qquad C_p = \beta^2 z + w \sum_{i=0}^{2} \beta^i = (\beta + \beta^2)p\theta + w_0 \sum_{i=0}^{2} \beta^i.$$

The value of C_p is the same as C_x so that pensions are as costly as ex post compensation.

Not all wage structures satisfying equation (11) are viable since this condition only ensures that the worker accepts the job. The temporal structure of the payments must be tilted toward the latter periods or else the worker will quit after an unfavorable outcome after having been overpaid initially. To prevent turnover in the final period,

$$(12) \qquad w + z \geq w_0 + \theta,$$

and to prevent turnover after the first period when the lottery outcome becomes known the wage structure must satisfy

$$(13) \qquad w + \beta(w + z) \geq (w_0 + \theta)(1 + \beta).$$

On dividing by $1 + \beta$, this condition is

$$(14) \qquad w + \frac{\beta z}{1 + \beta} \geq w_0 + \theta.$$

Since $\beta/(1 + \beta)$ is less than one, the second-period constraint in equation (14) is more stringent than the third-period requirement. Viewed somewhat differently, a firm cannot seek to retain workers with adverse experiences during period 2 and let them quit in period 3 because any wage struc-

ture that will retain them in the earlier period will do so in the final period as well.

In effect, the firm must pay a wage package in the final two periods with a discounted per period value of $w_0 + \theta$ or else turnover will result. Since the expected loss in each of these periods is only $p\theta$ at the time the job is accepted, workers are overpaid on an expected basis in the final periods and consequently can be underpaid initially. Rearranging equation (14) gives the form for the minimal pension as

$$z = \frac{1 + \beta}{\beta} (w_0 + \theta - w).$$

Substituting this value for z into equation (10) and solving for w produces the result that $w = w_0 + (\beta + \beta^2)\theta(p - 1)$. The worker takes a wage cut below his reservation wage in the first two periods and is compensated through his pension for both his expected loss and his initial underpayment. The worker must be overcompensated when viewed from the ex ante situation since his turnover choice is based on the actual lottery outcome, while his initial job acceptance decision is based on his expected prospects. The optimal wage structure is increasing over the worker's tenure with the firm. Finally, with only a single lottery, the worker is indifferent to the variations in the risk for any given mean initial risk level.

Unlike ex post compensation, pensions will serve as a perfect self-selection device. Even if workers' probability assessments p are subjective and potentially affected by learning, since there is only a single lottery being incurred, only the initial risk assessment is relevant. With a wage structure satisfying equation (11), those with risk assessments not exceeding p will find the job acceptable, while those with higher risk assessments will avoid the job. If the differences in risk perceptions arise from underlying heterogeneity in the risk, the efficiency of labor market matches will be enhanced by pensions, whereas with biased perceptions pensions serve primarily as a profit-making device. Since the situation being considered is that in which all workers remain at the firm, the gain from offering the pension does not arise because workers do not collect it. Moreover, the minimal wage outlays in periods 2 and 3 are unaffected by the assessed risk because the wage package must keep all workers after the lottery has been resolved. The financial gains for the firm arise from being able to lower the base wage as the worker's assessment of the chance of an unfavorable outcome declines.

When there is heterogeneity or misperception, there also will be an advantage to offering pensions even when turnover is permitted. Although paying a flat wage w_0 will only retain workers with favorable experiences, the proportion of workers with unfavorable outcomes will be higher if the firm does not offer a wage structure that self-selects only the low-risk workers. By shifting more of the compensation toward the latter periods,

pensions will screen out workers who have a higher perceived chance of an unfavorable lottery outcome.

If the wage-pension package permits turnover, then the worker who has an assessed risk will prefer to leave after an unfavorable outcome, or

$$w - \theta + \beta(w + z - \theta) < w_0 + \beta w_0.$$

To simplify the subsequent analysis I will assume that θ is so large that even if all compensation is through the pension (i.e., $w = 0$) the worker will leave after an unsuccessful outcome. As before, one can show that the most desirable z will be its maximum value consistent with turnover whenever workers underestimate p and consequently overestimate the chance of collecting the pension.

To attract a worker with risk assessment $\hat{p}$ to the job, z must satisfy

$$(\beta + \beta^2)\hat{p}w_0 + \beta^2(1 - \hat{p})z \geq w_0\sum_{i=0}^{2} \beta^i.$$

The least costly pension is consequently

$$z = \frac{w_0[1 + (\beta + \beta^2)(1 - \hat{p})]}{\beta^2(1 - \hat{p})} .$$

If p represents the true risk faced by the worker, which is assumed to be known by the firm, the discounted expected wage costs are

$$\beta^2(1 - p)z = \frac{(1 - p)}{(1 - \hat{p})} w_0[1 + (\beta + \beta^2)(1 - \hat{p})]$$

$$= w_0[\frac{1 - p}{1 - \hat{p}} + (\beta + \beta^2)(1 - p)].$$

Dividing by the discounted expected periods worked, the wage bill per period is

$$\frac{\beta^2(1 - p)z}{1 + (\beta + \beta^2)(1 - p)} = \frac{w_0[\frac{1 - p}{1 - \hat{p}} + (\beta + \beta^2(1 - p)]}{1 + (\beta + \beta^2(1 - p)} < w_0.$$

If there are misperceptions in which workers underestimate the risk, or $\hat{p} < p$, the wage-pension combination with turnover can lower the per period wage cost below w_0 by engaging workers in pension bets at unfavorable odds. Without misperception, $p = \hat{p}$, and there is no wage gain, but there is a reduction in the proportion of workers who quit because of adverse lottery outcomes.

8.4.2   Binary Failure Processes

A somewhat more complicated lottery structure is a binary failure process in which for all workers who have not yet experienced an adverse out-

come there is a chance p of a loss $-\theta$ in each period. As in the model in section 8.4.1, once this loss is incurred, the worker will suffer it in each of the remaining periods as well should he decide to remain with the firm. These assumptions best characterize situations in which a worker discovers that his job will be unpleasant, or he will be unproductive and consequently never promoted. Since θ also can be treated as altering the relative rewards of the job, one can view this situation as one in which the worker gets a permanent outside job offer. Instead of having a reservation wage w_0, he has a required wage $w_0 + \theta$ for the remainder of his work career.

For job lotteries of this type, it suffices to consider the implications in a two-period model. The flat wage option continues to impose as low costs as any alternative approach if worker turnover is permitted and if all workers assess the risk as p. The per period wage bill of w_0 is the same as the expected per period cost with pensions as well. Under pensions, however, the firm can potentially attract the low-turnover workers if there is heterogeneity in the risk assessments. With either legitimate risk differences or misperceptions, when some groups of workers have a risk assessment $\hat{p} < p$ pensions will impose the least costs.

As a means for preventing worker turnover, the flat wage is dominated since the wage must be $w_0 + \theta$ to achieve this result, leading to overpayment of all workers who, in each period, do not have adverse job experiences. Contingent wage payments offer a lower-cost method of preventing turnover in situations in which the lottery outcome can be monitored. The present value of the ex post compensation package is

$$C_x = w_0 + p\theta + \beta p(w_0 + \theta) + \beta(1 - p)[w_0 + p\theta]$$

or

$$C_x = w_0(1 + \beta) + \theta\{p + \beta[1 - (1 - p)^2]\}.$$

The contingent payment just compensates the worker for his reservation wage plus his on-the-job losses. With homogeneous risk assessments and accurate perceptions, this approach imposes the same costs as pensions; if all workers overassess the risk, ex post compensation continues to be less expensive.

Any viable pension package (w, z) offered by the firm must satisfy

(15)
$$\begin{aligned} w_0(1 + \beta) &= w - p\theta + \beta p \max[w_0, w + z - \theta] \\ &+ \beta(1 - p)\max[w_0, w + z - p\theta] = EU. \end{aligned}$$

Any wage structure with a nonnegative pension that attracts workers initially will retain them after a favorable first-period outcome, or

(16)
$$w + z - p\theta \geq w_0.$$

If pensions retain workers with an adverse initial job outcome,

(17)
$$w + z - \theta \geq w_0,$$

whereas if this condition is not met, turnover occurs for all workers with adverse initial job experiences.

In each turnover case, pensions meeting the conditions above will induce the self-selection of all workers with risk assessments below p. Biases in risk perception will, as before, make it desirable to shift income forward in time, particularly when workers overestimate the chance that they will collect the pension. Finally, the wage structure induced by pensions will always be upward sloping if pensions are designed to prevent turnover. Otherwise the firm in effect is operating within the context of section 8.2's compensating differential model except that all workers with unfavorable experiences in period 1 drop out of the sample.

The principal difference with the results in section 8.4.1 is the effect of variability in the risk p. If the compensation package is always adjusted to ensure that equation (15) holds, workers would be indifferent to such fluctuations. I will focus instead on workers on particular employment paths that will not be altered by minor variations in p, where the wage structure is viewed as exogenous. In this instance, the variability of p may be consequential.

Consider first the situation in which turnover is permitted, that is, equation (15) holds but equation (17) does not. The effect of altering p is given by

$$\frac{\partial EU}{\partial p} = -\theta + \beta w_0 + \beta(1 - p)(-\theta) - \beta(w + z - p\theta) < 0$$

and

$$\frac{\partial^2 EU}{\partial p^2} = 2\beta\theta > 0.$$

As in the learning case, workers' expected utility is convex in p.

Similarly, when no turnover occurs under the pension (i.e., eq. [17] holds), one obtains

$$\frac{\partial EU}{\partial p} = -\theta + 2\beta\theta(p - 1) < 0,$$

and

$$\frac{\partial^2 EU}{\partial p^2} = 2\beta\theta > 0.$$

In each case workers' expected utility is convex in p, as illustrated in figure 8.2. A lottery on the extreme certainty situations will, for any given employment path, be preferred to lotteries with intermediate probabilities.

Unlike the model in section 8.3, no learning was included in this analysis. The result pertaining to the effect on variability hinges not on changes

in the assessed risk but on the creation of an asymmetric lottery structure over time. In the learning case, there was no such asymmetry when no turnover occurred and $\partial^2 EU/\partial p^2$ equaled zero. Similarly, for the replicated identical lotteries in section 8.2 and the single lottery of section 8.4.1, the fact that whatever lottery was incurred never changed produced the result that workers were indifferent among all lotteries with the same initial risk level.

8.4.3   Deterioration Processes

These results must be altered somewhat if the job lotteries do not pose simply a chance of losing θ but a more general risk in which the attractiveness of the job may steadily deteriorate. Either the attractiveness of the job itself may steadily decline or the job alternative may become increasingly attractive. If the worker receives outside offers with the option of recall, his reservation wage may rise to $w_0 + \theta$, then to $w_0 + \theta'$, where $\theta' > \theta$. For concreteness, I will treat the lottery in terms of a loss θ on one's present job, where this loss occurs with probability p. Once the initial loss θ has been incurred, the worker faces a chance p' that the loss will rise to θ'. Although p' need not equal p, this posibility is not ruled out.

Many of the results for this lottery structure follow a familiar pattern. In the two-period case, the flat wage that prevents turnover costs $C_f = (1 + \beta)(w_0 + \theta')$, which overpays all workers over the course of employment since it matches their highest reservation wage. Contingent compensation continues to be the least costly solution when risk perceptions are accurate, where

$$C_x = w_0(1 + \beta) + p\theta + \beta p p'\theta' + \beta p(1 - p')\theta + \beta(1 - p)p\theta.$$

Pensions can attract and retain workers at the same cost and, if there is heterogeneity in workers' risk assessments, they will serve as a self-selection device, whereas contingent compensation will not. Moreover, with heterogeneity or biased perceptions in which the risk is underestimated, pensions continue to impose fewer costs.

The role of the variability of the risk is somewhat different, however. Consider first the situation in which pensions prevent worker turnover. The present value of the pension pay package is

$$C_p = w + \beta(w + z)$$
$$= w_0(1 + \beta) + p\theta + \beta p[p'\theta' + (1 - p')\theta] + \beta(1 - p)p\theta,$$

and the worker's expected utility is

$$EU = w - p\theta + \beta p[w + z - p'\theta' - p(1 - p')\theta]$$
$$+ \beta(1 - p)(w + z - p\theta).$$

If p and p' are different,

$$\frac{\delta EU}{\delta p} = -\theta + \beta[w + z - p'\theta' - p(1 - p')\theta]$$

$$- \beta p(1 - p')\theta - \beta(w + z - p\theta) - \beta(1 - p)\theta < 0,$$

and

$$\frac{\delta^2 EU}{\delta p^2} = 2\beta\theta p' > 0.$$

Expected utility is convex in p, and the worker prefers a mixture of extreme lotteries to the lotteries with intermediate probabilities (see fig. 8.2). If, however, $p = p'$,

$$\frac{\delta EU}{\delta p} = -\theta + \beta[w + z - p\theta' - p(1 - p)\theta] + \beta p(-\theta' - \theta + 2p\theta)$$

$$- \beta(w + z - p\theta) + \beta(1 - p)(-\theta) < 0,$$

and

$$\frac{\delta^2 EU}{\delta p^2} = -2\beta\theta' + 6\beta p\theta.$$

Expected utility is convex in p if θ' is sufficiently small relative to θ, or, more specifically, if $3p\theta > \theta'$. For every large θ' the EU function is bowed outward, and the worker prefers an intermediate lottery to a mixture on extremes with the same expected initial risk. The reason for this reversal is that with extreme p values the worker has a greater chance of incurring the successive losses θ and θ'.

For very large θ' the firm will not find it attractive to retain the worker unless turnover costs are very high. In instances in which turnover occurs, the discounted expected pension cost is

$$C_p = w + \beta(1 - p)(w + z) = w_0 + p\theta + \beta(1 - p)(w_0 + p\theta).$$

The worker's expected utility is given by

$$EU = w - p\theta + \beta p w_0 + \beta(1 - p)(w + z - p\theta),$$

which is the same as in the binary failure case in section 8.4.2. In this situation EU is convex in p.

8.5   Conclusion

The only job lottery situation in which pensions do not play a useful role is the standard compensating differential model in which workers face an identical sequence of lotteries over time and never leave the job after starting it. In all other situations, pensions and other forms of rising earnings profiles can achieve the same desired turnover properties for

risk-neutral workers as does ex post compensation. Moreover, unlike contingent compensation, there is no need to monitor the lottery outcome.

If workers have heterogeneous risk perceptions, pensions offer an additional advantage even in situations in which turnover is not a matter of concern. By self-selecting the workers with low risk assessments and, in the biased perceptions case, by enabling the firm to make unfair bets with workers, pensions reduce firms' wage costs.

The welfare implications and the efficiency of the job matches will, however, be quite different depending on the source of the heterogeneity. If some workers underestimate the risk, pensions will create incentives that will lead to the self-selection of workers into the job. Workers may then be trapped inefficiently based on the true risks, and those workers who leave will forfeit their pension benefits.

The fact that pensions trap some workers in jobs they would like to leave does not in itself suggest that workers entered jobs with biased perceptions. Even with accurate perceptions, ex post workers who have experienced unfavorable lottery outcomes may be on jobs they wish to leave, but to which their forfeitable pensions tie them. The existence of a negative pension-turnover relationship and dissatisfaction among immobile workers does not necessarily provide a rationale for mandatory vesting requirements.

The variability of the risks faced by workers also plays a critical role. Except in the case of single or replicated identical lotteries and one instance of the deterioration process, workers' expected utility is convex in p. A lottery on extreme, more stable employment paths is preferred to the situation in which workers face an intermediate risk each period. In the presence of learning, jobs associated with less precise priors are perferred. Since less precise priors make possible a wider divergence of posterior-assessed risks, the underlying principle involved is quite similar.

A recurring theme in these results is that the design of the compensation structure in situations of uncertainty is quite sensitive to the structure of the uncertainty the worker encounters. Although pensions serve no productive function in the presence of lottery structures such as those considered in the compensating differential literature, the other forms of uncertainty considered suggest that pensions have a legitimate role to play as a compensation instrument. Situations of learning are one such stochastic structure, but learning is by no means required for pensions to serve a useful function.

In the presence of uncertainty and turnover costs, nontransferable pensions can be important in self-selecting more stable employees and reducing the turnover of workers attracted to the firm. Unfortunately, if workers have biased perceptions, pensions will be offered by employers even in situations in which there would be no cost reductions from pensions if workers were fully informed. The possibility of such abuses may create a potential rationale for collective action.

Notes

1. For further description of the turnover-related benefit provisions see Ellwood (in this volume) and Kotlikoff and Smith (1983).

2. Three representative studies are Viscusi (1979), in which I focus on dummy variables for whether or not the worker was covered by a pension; Schiller and Weiss (1979), who analyze a series of variables related to pension characteristics; and Mitchell (1982), who uses pension dummy variable and a survey that was the sequel to the data set I examined.

3. This point was first made by Becker (1964).

4. See Viscusi (1983) for the results presented in terms of time-varying wage rates. Analogous findings are presented for pensions in a preliminary form of the paper, "Specific Information, General Information, and Employment Matches under Uncertainty," NBER Working Paper no. 394 (1979).

5. This analysis is presented in Lazear (1984).

6. The forced savings argument presupposes that the worker wishes to be tied to a "Christmas club"-type plan for old age. It may be that forced savings lead to an inefficiently large deferral of savings for old age.

7. The loss need not be financial, but I will assume that it can be converted into a nonmonetary equivalent. The uncertainty could be with regard to worker productivity, which in turn affects output. This case, which I consider in Viscusi (1983), yields similar results but is a bit more complicated to analyze.

8. The results in this section generalize to n periods by simply changing the range of the summation in the equation below and by letting the discount factor multiplying pensions z be β^{n-1}.

9. Ex post compensation also may eliminate lotteries that serve a productive function. If the worker is assured of making his piecework quota or if he is guaranteed a promotion, there will be less incentive for him to work hard. These concerns arise in situations in which employers may pay workers according to relative performance because of the difficulty in monitoring performance. See, e.g., Lazear and Rosen (1981), and O'Keeffe, et al. (1984).

10. For treatments of self-selection in somewhat different contexts, see Salop and Salop (1976) and Viscusi (1979).

11. In the n-period case, the analysis becomes quite complicated. Although the worker will always remain on the job after a favorable outcome on the previous trial, how soon he chooses to switch jobs cannot in general be ascertained. Since the value of $p(m, n)$ is continually changing, the problem is not amenable to closed-form solutions such as one encounters in the job search literature. The most that can be determined is that there is a quite broad range of turnover possibilities.

12. Moreover, so long as the downward tilt is not too great the worker will not leave after a success. Although the relative shapes generally hold, the various curves may intersect the horizontal axis rather than the vertical axis. In the extreme case, one might never leave the job for any (p, γ) combination, or one might never be willing to start the job. In these situations, the wage structure can be redesigned to provide the desired turnover properties.

13. This definition of increasing risk is adopted by Rothschild and Stiglitz (1970).

Comment   Sherwin Rosen

This paper discusses how nonvested pensions affect labor mobility (quit) decisions of workers who are only imperfectly informed of some job attribute and who become better informed of it through on-the-job

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experience. We know from previous work that the use of deferred pay biases self-selection toward more stable workers. Unstable workers find these jobs less attractive because they have a larger chance of losing much of their pay by quitting before the pension is received. Viscusi extends this argument in a subtle and sophisticated way to incorporate worker uncertainty on how the job matches to workers' prior perceptions.

In a world where long-term contracts are not binding on workers, the option of quitting increases the value of greater initial uncertainty about job outcomes. The reason is similar to why a stock-market option has greater value when risk increases: quitting truncates the lower tail of the distribution and induces new workers to gamble that a favorable outcome will be realized, since losses are limited. This has two effects: First, workers who are initially misinformed about conditions take the job at low wages in the hope that conditions turn out to be favorable. In that case the pension is received. If the outcome is unfavorable, they quit and forgo their pension. The firm makes money on this and takes advantage of quitters in calculating the optimal life-cycle wage policy. Second, given the subset of workers who do not leave because of insufficiently unfavorable realizations, nonvested pensions make it more costly to quit: some workers invariably are trapped into jobs they do not like.

The paper concentrates on self-selection constraints. These are the supply conditions confronting the firm, given the distribution of worker prior perceptions and their optimal stopping rules based on experience. This is an interesting exercise because so little has been written on how perceptions and misperceptions affect choices. Nonetheless, one wonders why the next logical step was not taken. Why not specify and analyze the maximum problem for the firm subject to the constraints that have been so thoroughly discussed?

Such a problem would clarify the advantages to the firm of reducing turnover, which play very little role in the formal analysis. It would also introduce other interesting factors, including incentives for the firm to affect the loss and the probability of the adverse outcome, as well as workers' prior perceptions of them. As the paper stands, firms are totally passive. They merely adopt a wage policy, and the onus of staying or leaving is put entirely on the worker. Yet as I recall the testimony surrounding the passage of ERISA, it was not only the complaints of the workers locked into large pensions or those who voluntarily quit their jobs that led to pension reforms. The horror stories of workers who were involuntarily terminated prior to vesting were also important considerations.

The incentives for a firm to engage in such behavior are clear enough. Any backloaded pension-wage contract involves an element of bonding by the worker. The worker effectively lends money to the firm, because the first-period wage is less than the opportunity cost. The worker gets the bond back, plus interest, only if he stays long enough to collect it. The firm gains, myopically to be sure, by reneging in the second period and

terminating the worker prior to receipt of the pension, similar to default on a loan. No doubt cheating of this sort is limited by longer-run considerations, such as loss of reputation. Nonetheless, marginal analysis suggests that a little cheating will persist in equilibrium. For example, in those cases involving close calls about probable cause of termination, the probability of the firm's committing type II error in discharges is increased. One wonders how a more complete treatment of this problem would change the positive and normative nature of the results and suggest alternative reforms.

One hopes in subsequent work that more attention will be paid to the empirical predictions of the model. What does the model say about the circumstances under which nonvested pensions will be an important consideration? When will they be observed? In fact, as it stands, wage variations in a multiperiod model could easily perform the same self-selection role as pensions do. It is the wage gradient that is important to the model, not pensions per se, because there are no end period unraveling conundrums in this problem. Be that as it may, the interest of the work would be considerably enhanced if it were related to some conceivable data. Perhaps a good place to start thinking about these problems concretely is in the military, where nonvesting is complete up to 20 years of service. In this instance, pensions not only save resources by avoiding retraining through retention of skilled personnel, they also assist in solving an important principal-agent problem. The threat of getting cashiered and losing one's pension makes enlistees better soldiers. Surely considerations such as these are relevant to all organizations.

Finally, the paper restricts self-selection schemes to virtually one parameter, namely, the gap between the first- and second-period wage. Yet selection occurs over two parameters: the prior probability and its precision. One suspects that two instruments—the gap plus something else— would be necessary to sort people in a more efficient manner. This is complicated by the fact that initially homogeneous workers become heterogeneous through differential experience. I have not been creative enough to identify precisely what that second instrument might be, though the risk-is-good argument suggests that randomization schemes and lotteries might be useful candidates to consider.

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