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7 The Pension Inducement to Retire: An Option Value Analysis

James H. Stock and David A. Wise

The labor force participation rates of older workers have declined dramatically in recent years. The data for men show the trend:

	Age			
Year	50–54	55–59	60–64	65+
1971	92.8	88.8	74.1	25.5
1986	88.9	79.0	54.9	17.5

A great deal of analysis has emphasized the role of Social Security provisions in encouraging earlier retirement. Recent examples are Blinder, Gordon and Wise (1980), Burkhauser (1980), Hurd and Boskin (1981), Gustman and Steinmeier (1986), Burtless and Moffitt (1984), Burtless (1986), and Hausman and Wise (1985). Several of these papers direct attention to the large increases in Social Security benefits in the early 1970s. These papers for the most part show only a modest effect of these increases on labor force participation rates; Hurd and Boskin (1981) is an exception.

Largely ignored have been firm pension plans. Firm pension plans were introduced rapidly beginning in the 1950s. Now about 50 percent of employees

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are covered by firm plans. The proportion of retiring workers that is covered by a firm pension has risen rapidly. It increased from about 4 to 25 percent between 1950 and 1980 and is still increasing. About 75 percent of covered employees have defined benefit plans. The benefit under such a plan is the promise by the employer to pay the worker a specified amount at retirement. The amount is typically determined by final salary and years of firm employment. Bulow (1981) described pension wealth accrual under these plans, and Lazear (1983) emphasized the potential role of plan provisions in inducing early retirement, as a substitute for mandatory retirement. The very substantial incentive effects of these plans have been emphasized most recently by Kotlikoff and Wise (1985, 1987, 1989), who summarize the incentives of approximately 2,500 plans covered by the Bureau of Labor Statistics Level of Benefits Survey and consider in great detail the effects of the provisions of a large *Fortune* 500 firm. This work demonstrates that the typical firm plan provides a large reward for remaining with the firm until some age, often the early retirement age, and then a substantial inducement to leave the firm, often as early as 55. Almost all plans incorporate a large penalty for working past age 65. The gain in wage earnings from working an additional year is often offset in large part by a loss in the present value of future pension benefits.

There has been very little analysis of the actual effects of these incentives on retirement, however. Exceptions are Burkhauser (1979), Fields and Mitchell (1982), Lazear (1983), Kotlikoff and Wise (1987), and Hogarth (1988). One reason for the limited attention has been the absence of appropriate data. The analysis in this paper is based on the personnel records of a large *Fortune* 500 firm. The firm pension plan was described in detail by Kotlikoff and Wise (1987), who also related the plan provisions to departure rates from the firm.

The goal of this paper is to quantify the effects of pension plan provisions on departure rates from the firm and, in particular, to demonstrate the effect of potential changes in plan provisions. A particularly important component of the analysis is to demonstrate the relative effects of changes in Social Security versus firm pension plan provisions. The analysis is based on the "option value" model developed in Stock and Wise (1988).

The primary conclusions are:

- Firm plans have a much greater effect than Social Security provisions on employee retirement decisions.
- The effect of changes in Social Security provisions that are intended to prolong the labor force participation of the elderly, like the planned increase in the retirement age, may be offset by the response of firms to the change.

We begin in section 7.1 with a description of the incentive effects faced by workers in the firm. The description of the incentive effects is also used to motivate our method of analysis. The option value model and parameter estimates are summarized in section 7.2. Simulations of the effect on departure rates of changes in firm pension plan and in Social Security provisions are discussed in section 7.3. A summary and concluding discussion is provided in the last section.

7.1 The Firm Pension Plan and Retirement Incentives

The analysis in this paper is based on salesmen who are at least 50 years old and have been employed for at least three years.[1] To understand the effect of the pension plan provisions, consider several figures. Figure 7.1 shows the expected future compensation of a person from our sample who is 50 years old and has been employed by the firm for twenty years.[2] It is important to consider total compensation—including wage earnings, the accrual of pension benefits, and the accrual of Social Security benefits. As compensation for working another year, the employee receives salary earnings. He also receives compensation in the form of future pension benefits. The annual compensation in this form is the change in the present value of future pension benefits, due to working an additional year. This accrual is comparable to wage earnings. The accrual of Social Security benefits may also be calculated in a similar manner and is also comparable to wage earnings. Figure 7.1 shows the present value at age 50 of expected future compensation in all three forms. The line labeled earnings represents cumulated earnings, by age of retirement.[3] For example, if the person were to retire at age 62, his cumulated earnings between age 50 and age 62, discounted to age 50 dollars, would be about $300,000. The slope of the earnings line represents annual earnings discounted to age 50

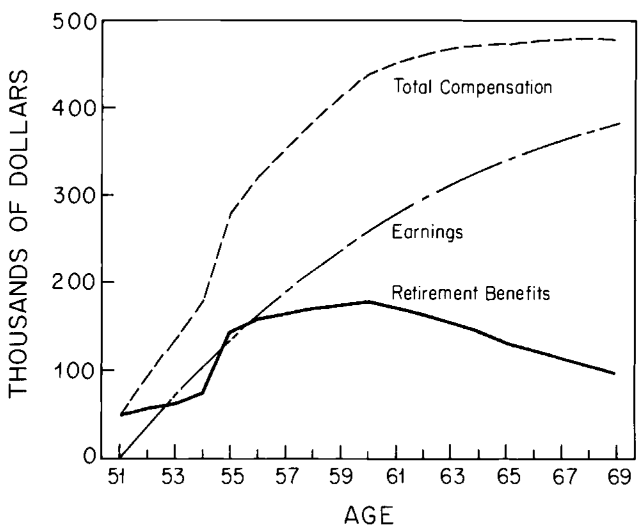

Fig. 7.1 Future compensation of a typical employee

dollars. Earnings decline rather slowly through age 60 and much more rapidly thereafter.

The solid line shows the present value of pension plus Social Security benefits, again discounted to age 50 dollars. The shape of this profile is determined primarily by the pension plan provisions. The most important provisions are described here.[4] An employee could leave the firm at age 53, for example. If he were to do that, and if he were vested in the firm's pension plan—which occurs after ten years of service—he would be entitled to normal retirement pension benefits at age 65, based on his years of service and *current* dollar earnings at age 53. He could start to receive benefits as early as age 55, the pension early retirement age, but the benefit amount would be reduced actuarially. If he started to receive benefits at age 55, they would be only 36 percent of the dollar amount he would receive at age 65. If, however, he were to remain in the firm until the early retirement age, the situation would be quite different. He would be entitled to normal retirement benefits based on his years of service and salary at age 55. But, if he were to start to receive them at age 55, the benefits would be reduced less than actuarially, about 3 percent for each year that retirement precedes age 65, instead of 6 or 7 percent. In addition, the plan has a Social Security offset provision. Pension benefits are offset by a specified amount, depending on the firm estimate of Social Security benefits. But if the person takes early retirement, between 55 and 65, the Social Security offset is not applied to benefits received before age 65. These two provisions create the large discontinuous jump in retirement benefits at age 55; there is an enormous bonus for remaining with the firm until that age. After age 55, however, the person who does not retire forgoes the opportunity of taking pension benefits on very advantageous terms—thus the minimal change in the discounted value of benefits between 55 and 60. If a person has thirty years of service at age 60, he is entitled to full normal retirement benefits. No early retirement reduction is applied to benefits if they are taken then. That is, by continuing to work he will no longer gain from fewer years of early retirement reduction, as he did before age 60. Thus, the kink in the profile and the decline thereafter.

The top line shows total compensation. The large jump at 55 reflects the early retirement provisions of the pension plan. Total compensation declines modestly each year through age 60 and very rapidly thereafter. After age 62 or 63, total compensation is close to zero. Under these circumstances, it would be surprising if this person were to continue to work until age 65.

The graph can also be used to motivate the option value model used in the subsequent analysis. Suppose that the person depicted in figure 7.1 is considering whether to retire now, at age 50. If he does, he will receive utility indirectly from the retirement benefits that he will receive until he dies. (In fact, he will not be able to receive firm pension benefits until age 55, and Social Security benefits cannot be taken until age 62.) If he leaves the firm at age 50, though, he forgoes the option of retiring at some future age. In this case, there will be a large increase in pension benefits at age 55, and thus a jump in total lifetime income, if he postpones retirement until then. Some later age may be even more advantageous. In particular, if he does not retire, he maintains the option of retiring at the future age that for him yields the highest expected utility. The central feature of the option value model is that the person will postpone retirement at age 50 if, based on his expectations at age 50, the best of the future possibilities is better than retiring now. That is, he postpones retirement if the value of the option to retire later exceeds the value of retiring today. At each subsequent age, he will make the same comparison. At some age, future retirement possibilities will look worse than immediate retirement, and he will leave the firm.

It is clear that the early retirement provisions in this firm are likely to have an important effect on retirement decisions. The qualitative effect of changing the early retirement age can be seen by comparing figures 7.1 and 7.2. Figure 7.2 describes the expectations of the same person considered in figure 7.1, except that the firm early retirement age has been shifted from 55 to 60, with all other plan provisions remaining unchanged. It is apparent that the person would under these provisions be much less likely to retire before age 60. Estimates of the effects of such a change are presented below.

To calculate the amounts graphed in figures 7.1 and 7.2, future income is discounted at a 5 percent real interest rate and no distinction is made between individual valuation of wage earnings versus pension benefits. To predict retirement, however, the relevant values are not these but rather the discounted value of future utilities based on the weights that individuals assign to future income streams in determining whether to retire. Such values are estimated in

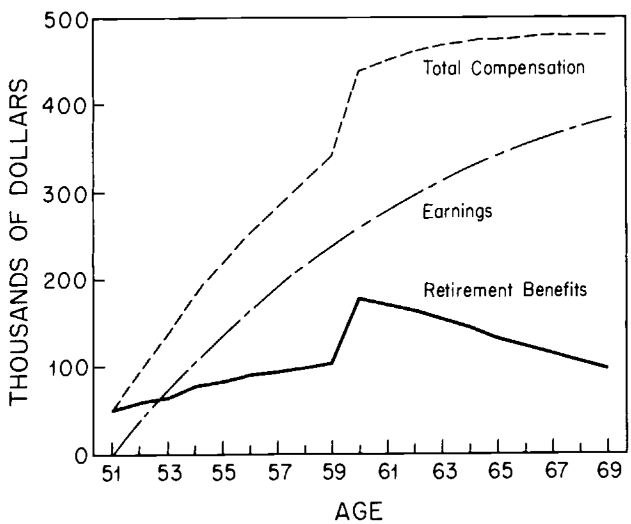

Fig. 7.2 Future compensation with early retirement at 60 instead of 55

the subsequent analysis. As it turns out, the estimated discount rate is much higher than 5 percent, and individuals value a dollar of retirement benefits much more than a dollar of wage earnings; a dollar without work is better than a dollar with work. Based on our parameter estimates, the graph, from the point of view of the individual, would look like figure 7.3 instead of figure 7.1. Based on these valuations of future income streams, the person depicted in figure 7.1 would be much more likely to retire before age 60, say, than is in fact suggested by figure 7.1.

Persons of the same age face very different options depending on years of service and earnings histories. A comparison of figures 7.1 and 7.4 demonstrates this point. The person whose expected future options are shown in figure 7.4 has only three years of service when he is 50 years old. He will not have thirty years of service until he is 77. He will not be vested until he is 57. Compared to the person in figure 7.1, this person would apparently be much less likely to retire before age 65.

Finally, consider a person who is still working at age 58 in 1980. He has eighteen years of service. His expected future options are shown in figure 7.5. Although his wage earnings will decrease only slightly in the next ten years, the present value of retirement benefits will decline almost continuously. The graph suggests that retirement would be likely around 63 or 64. It was clear from a comparison of figures 7.1 and 7.2 that changing the firm early retirement age from 55 to 60 would have a substantial effect on retirement. The potential effect of changes in Social Security provisions can be seen by altering the options faced by the person described in figure 7.5. The current Social Security rules reduce benefits by 5/9 of a percent for each month that benefits

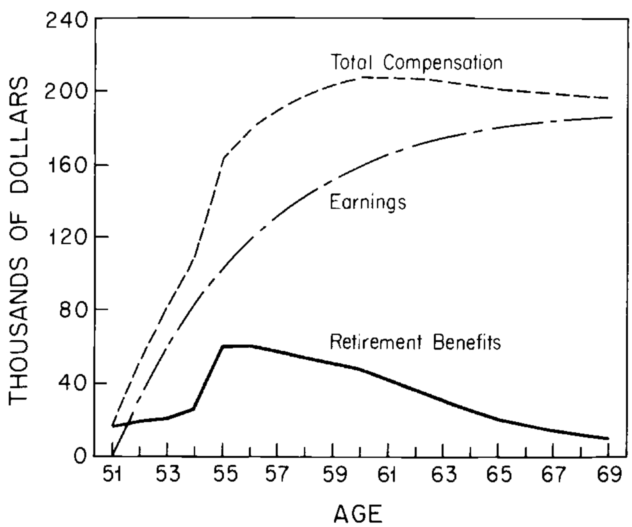

Fig. 7.3 Future compensation based on estimated valuation of future income

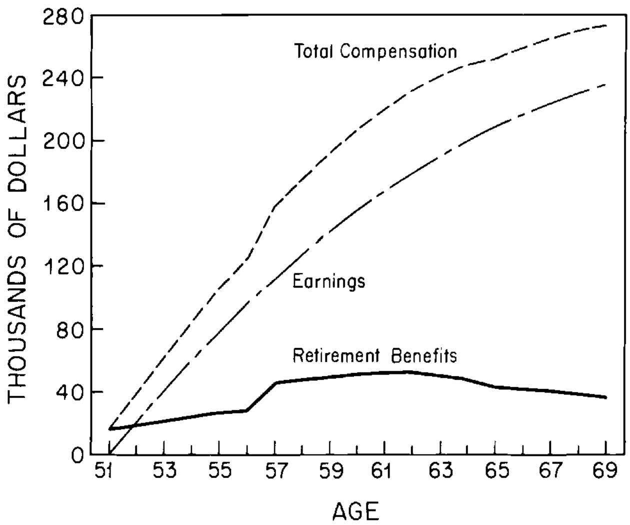

Fig. 7.4 Future compensation for a person with only three years of service at age 50

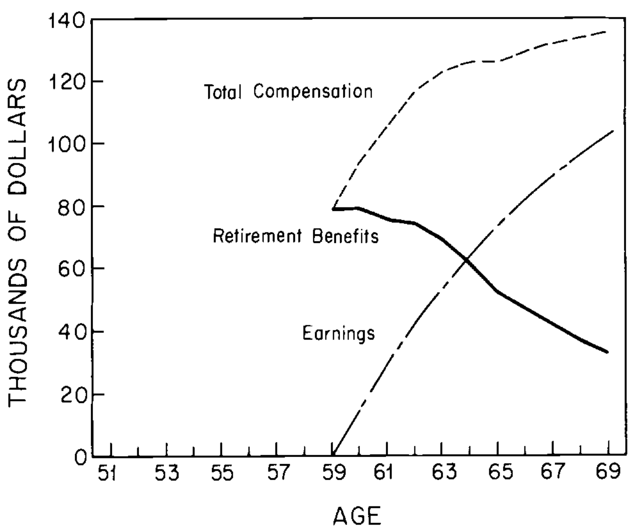

Fig. 7.5 Future compensation from age 58

are taken before age 65. Suppose that the reduction were 1 percent per month instead of 5/9. The effect on the options faced by the figure 7.5 person are shown in figure 7.6. The effect is noticeable, but not extreme. The value of retirement benefits before age 65 has been shifted downward, and thus total income associated with retirement before age 65 has been shifted downward.

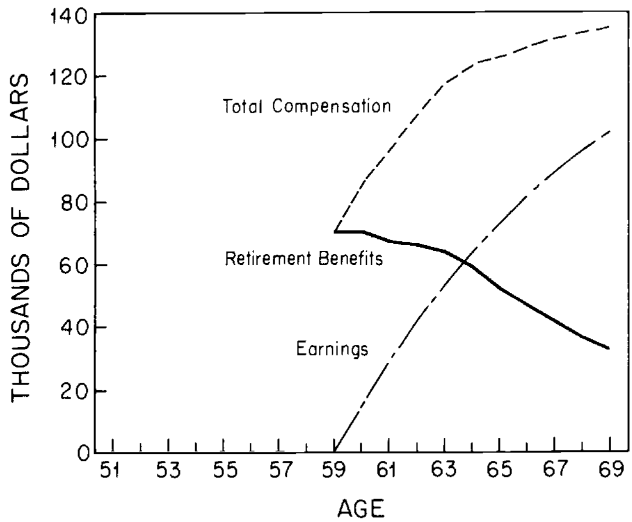

Fig. 7.6 Future compensation from age 58 with the Social Security early retirement reduction at 1 instead of 5/9 percent

The result would apparently be a lower likelihood of retirement between 62 and 65, judging by the change in the graph. Actual estimates of the effect of such a change in Social Security provisions are presented below.

7.2 The Option Value Model and Estimation Results

7.2.1 The Model

The details of the option value model are presented in Stock and Wise (1988). The key elements of the model are summarized here.[5] Assume that the value $V_t(r)$ of working from age t to age $r - 1$ and then retiring can be measured by the indirect utility from future earnings and retirement benefits. It is described by

$$(1) \qquad V_t(r) = \sum_{s=t}^{r-1} \beta^{s-t} U_w(Y_s) + \sum_{s=r}^{S} \beta^{s-t} U_r[B_s(r)].$$

If the person continues to work, his wage earnings in year s are given by Y_s and the indirect utility from these earnings by $U_w(Y_s)$. The weight assigned to future utility, in the determination of the retirement decision, is β. If he retires in year r, he will receive retirement benefits $B_s(r)$ in subsequent years s, which he values according to the function $U_r[B_s(r)]$. As explained above, a person's retirement benefits will depend on his age and years of service at the time of retirement r as well as on his earnings history—thus the notation indicating that

B_s is a function of r. (We adopt the convention that, if s is the first calendar year during which the person has no wage earnings, he is assumed to have retired at the age that he was on 1 January of year s.)

Thus $E_tV_t(r)$ is the expected value at age t from working through age $r - 1$ and retiring at age r, and $E_tV_t(t)$ is the expected value associated with current retirement. Suppose that r^* is the value of r that maximizes $E_tV_t(r)$. The person postpones retirement at age t if $G_t(r^*)>0$. That is, the decision rule that we assume is: Postpone retirement if

$$(2) \qquad G_t(r^*) = E_tV_t(r^*) - E_tV_t(t) > 0.$$

If $G_t(r^*) < 0$, the person retires at age t. Thus $G_t(r)$ is the retirement decision function.

Following Stock and Wise (1988), the two indirect utility functions are specified as

$$(3) \qquad U_w(Y_s) = Y_s^{\gamma} + \omega_s ,$$

$$U_r(B_s) = [kB_s(r)]^{\gamma} + \xi_s ,$$

where ω_s and ξ_s are individual-specific random effects. The parameter k is to recognize the possibility that a dollar with leisure—while retired—is better than a dollar that is only had together with work. The random terms reflect a variety of unobserved differences among individuals. The values that individuals attach to wage and pension income may differ. Some persons may enjoy work more than others; some may enjoy retirement more than others. Both may be affected by health status, for example. Retirement decisions are likely to be affected by assets, other than pension wealth, which we do not measure. Such differences will be reflected in different values of ξ. In addition, we consider retirement to be the alternative to continued employment with the firm. For some, especially the younger persons in the sample, the alternative may well be another job. The utility of the alternative to work in such cases will presumably be greater than the utility represented by $U_r(B_s)$ for the typical person. These differences too will be reflected in different values of ξ. (The heteroskedastic error structure that the model implies, as explained below, is well suited to capture the effects of alternatives other than retirement, with the likelihood of such an alternative greatest for younger employees.)

Differences in preferences for work versus retirement, differences in health status, and other individual differences are likely to persist. Thus, these terms are assumed to follow a random walk over time. That is,

$$(4) \qquad \omega_s = \omega_{s-1} + \epsilon_{\omega s}, \quad E_{s-1}(\epsilon_{\omega s}) = 0,$$

$$\xi_s = \xi_{s-1} + \epsilon_{\xi s}, \quad E_{s-1}(\epsilon_{\xi s}) = 0.$$

We adopt the convention that at time s the individual knows ω_s and ξ_s; his forecasts of future ω and ξ are based on (5). The random walk assumption means, for example, that, if a person's health status worsens between periods t and $t + 1$, his expected health status in period $t + 2$ is not what it was in period t but rather what it was in period $t + 1$.

As shown in Stock and Wise (1988), with the substitution of the specifications (3) and (4), $G_t(r)$ may be decomposed into two terms, one depending on the individual-specific random terms ω_s and ξ_s, the other depending only on forecasts of measured variables. They are given by

$$(5) \qquad g_t(r) = \sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)E_t(Y_s^{\gamma}) + \sum_{s=r}^{S} \beta^{s-t}\pi(s|t)\{E_t[kB_s(r)]^{\gamma}\} - \sum_{s=t}^{S} \beta^{s-t}\pi(s|t)\{E_t[kB_s(t)]^{\gamma}\}$$

and

$$(6) \qquad \phi_t(r) = \left[\sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)\right](\omega_t - \xi_t) = K_t(r)\nu_t ,$$

where $\nu_t = (\omega_t - \xi_t)$, $K_t = \Sigma_{s=t}^{r-1}\beta^{s-t}\pi(s|t)$, and $\pi(s|t)$ denotes the probability that the person will be alive in year s, given that he is alive in year t. The further r is in the future, the larger is $K_t(r)$. That is, the more distant the potential retirement age, the greater the uncertainty about it. This yields a heteroskedastic disturbance term.

In short, $G_t(r)$ may be written simply as

$$(7) \qquad G_t(r) = g_t(r) + K_t(r)\nu_t .$$

The probability of retirement is easily described using this expression. If $r^{\dagger}$ is the r that yields the maximum value of $g_t(r)/K_t(r)$, the probability of retirement becomes

$$(8) \qquad \Pr[\text{retire in year } t] = \Pr[g_t(r^{\dagger})/K_t(r^{\dagger}) < -\nu_t].$$

To predict whether a person in the sample in year $t - 1$ retires in year t, equation (8) is all that is needed. Finally, we assume that ν_t is normally distributed with variance σ_ν^2. The parameters to be estimated are γ, k, r (where $\beta = 1/[1 + r]$), and σ_ν.

In fact, we are able to follow persons in the sample for five consecutive years. The analysis in this paper, however, is based only on data for one year. Retirement probabilities for several years may be derived as a simple extension of (8); they are shown in Stock and Wise (1988), together with estimates based on several consecutive years for each person.[6]

7.2.2 Parameter Estimates

Evaluation of $g_t(r)/K_t(r)$ requires estimates of future earnings. Individual forecasts are based on a second-order autoregression that recognizes individual differences in earnings potential and accounts for past evidence of earnings increases. The autoregression was estimated using the individual earnings histories of all salesmen employed at least three years, with earnings converted to 1980 dollars using the Consumer Price Index. The parameters of the forecasting model depend on age, years of service, and an interaction term.

The option value model parameter estimates (and standard errors) are[7]

γ	k	β	$\sigma_\nu(\times 10^5)$	$\mathcal{L}$
.632	1.25	.781	.099	−506.86
(.088)	(.28)	(.121)	(.018)	

All the parameters are measured quite precisely, with the possible exception of the weight β. The estimated γ of .632 means that the utility function exhibits modest risk aversion. The estimated value of k means that a dollar without work is worth 1.25 times a dollar gotten by working. In other words, the typical person would be willing to exchange a dollar with work for eighty cents without work. This suggests, loosely interpreted, that retirement benefits that replaced 80 percent of wage earnings would make a person indifferent between work and retirement. In the retirement decision, the estimated weight given to income one year in the future versus now is .781; income five years hence is given about half as much weight as income today. The variance term σ_ν, \$9,900, should be interpreted relative to the present value of future income. Typical values are indicated by the graphs at the beginning of the paper.

In general, the model fits the data well. Actual versus predicted retirement rates are shown in table 7.1 and in figure 7.7. As discussed in Stock and Wise (1988), the simulated average retirement rates by age are typically not significantly different from the sample averages. The only exceptions are at ages 62 and 65. There is apparently a "customary retirement age" effect that is not captured by the model. Unlike other models of retirement, age enters the option value model only indirectly—through the survival probabilities, the earnings forecasts, and the firm pension plan and Social Security rules.

The proportion of those in the firm at age 50 that would remain at age 54, based on actual retirement rates, is .179; the predicted proportion is .190. This suggests that, even though measured variables may often not evaluate correctly the alternative to continued work in the firm for younger employees, the error specification allows enough flexibility that the model predictions are still quite accurate. At older ages, the model predicts quite well the proportion of employees who have left the firm, as shown in figure 7.7.[8]

Table 7.1 Predicted and Actual Retirement Rates by Age for 1980[a]

Age	Number of Observations	Retirement Rates		Cumulative Rates	
		Actual	Predicted	Actual	Predicted
50	108	.037	.057	.037	.057
51	132	.030	.052	.066	.105
52	121	.041	.046	.105	.146
53	107	.047	.031	.147	.173
54	107	.037	.020	.179	.190
55	126	.087	.119	.250	.286
56	129	.116	.129	.337	.378
57	114	.123	.160	.419	.478
58	111	.126	.156	.492	.560
59	118	.153	.194	.570	.645
60	102	.206	.207	.658	.719
61	71	.197	.247	.726	.788
62	70	.471	.339	.855	.860
63	49	.286	.365	.896	.911
64	19	.474	.385	.945	.945
65	12	.583	.286	.977	.961
66	4	.750	.306	.994	.973

[a]The retirement rates were computed for the 1,500 persons used to estimate the model.

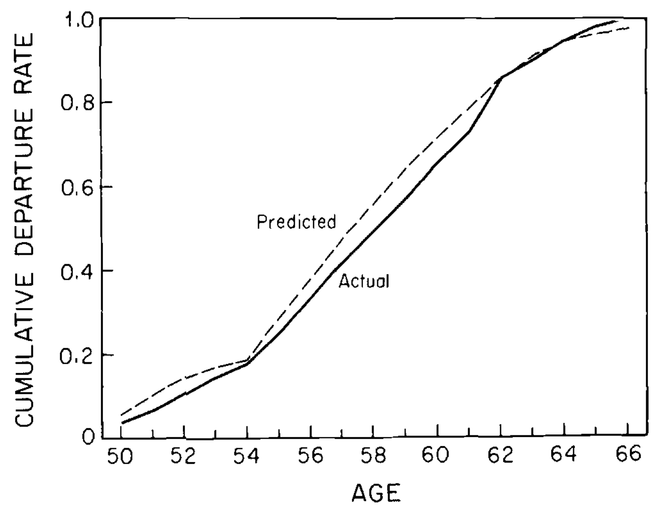

Fig. 7.7 Actual versus predicted cumulative departure rates

7.3 Simulations of the Effects of Changes in Pension and Social Security Provisions

We have used the model to simulate the effect of several potential changes in the firm pension plan and in Social Security provisions. We conclude that potential changes in the firm pension plan have a much greater effect on retirement rates than changes in Social Security rules. Four changes are considered.

7.3.1 Increase the Firm Early Retirement Age from 55 to 60

The effect of increasing the firm's early retirement age from 55 to 60, leaving other provisions as they were, is shown in table 7.2 and is graphed in figure 7.8. Under the current plan, 64.5 percent of those employed at 50 have left by 59. Only 42 percent would have left by age 59 if early retirement had been at 60 instead of 55. Only 13.6 percent of employees leave between 55 and 59 if early retirement is at 60, whereas 45.5 percent leave between these ages under the current system. On the other hand, because the early retirement "bonus" is now farther in the future, more employees leave the firm between 50 and 54. This is the result of the greater weight given to current versus future income. In short, many more workers would be employed between the ages of 57 and 65 if the early retirement age were 60 instead of 55.

Table 7.2 Simulation: Increase the Firm Early Retirement Age from 55 to 60

	Retirement Rates			Cumulative Rates		
Age	Base	Simulation	Difference	Base	Simulation	Difference
50	.057	.065	.008	.057	.065	.008
51	.052	.065	.013	.105	.126	.021
52	.046	.067	.021	.146	.185	.039
53	.031	.062	.031	.173	.235	.062
54	.020	.067	.047	.190	.286	.096
55	.119	.056	−.063	.286	.326	.040
56	.129	.049	−.080	.378	.359	−.019
57	.160	.050	−.110	.478	.391	−.087
58	.156	.035	−.121	.560	.413	−.147
59	.194	.016	−.178	.645	.422	−.223
60	.207	.207	[a]	.719	.542	−.177
61	.247	.247	[a]	.788	.655	−.133
62	.339	.339	[a]	.860	.772	−.088
63	.365	.365	[a]	.911	.855	−.056
64	.385	.385	[a]	.945	.911	−.034
65	.286	.286	[a]	.961	.936	−.025
66	.306	.306	[a]	.973	.956	−.017

[a]For persons employed at age 60 and older, the simulated alternative is the same as the base case.

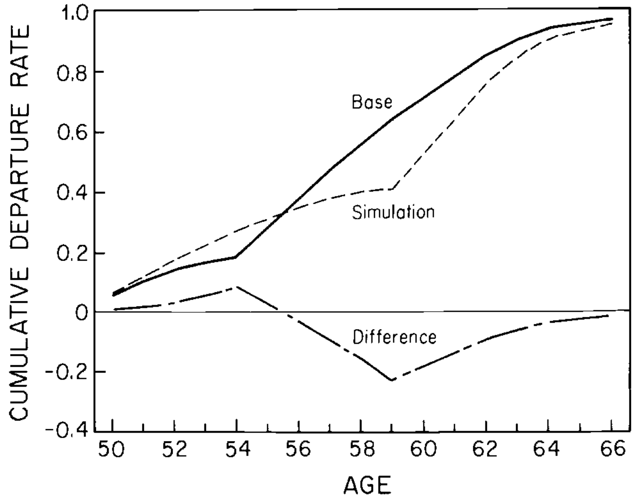

Fig. 7.8 Simulation: increase firm early retirement age from 55 to 60

7.3.2 Increase the Social Security Early Retirement Reduction Factor

The current Social Security rules include a benefit reduction of 5/9 percent per month of retirement before age 65. We consider the effect of increasing the reduction factor to 1 percent per month. The results are shown in table 7.3 and graphically in figure 7.9. It is clear that the effect of this change is small relative to the effect of the change in the firm early retirement age. This is primarily because only a small fraction of firm employees are still working at age 62, only 14 percent in the base case. The retirement rates of those still employed at age 62, however, are considerably lower—about 29 percent—with the higher reduction factor. They are also lower at 63. Still, the net result on the employment of persons covered by the firm's pension plan is negligible.

7.3.3 Increase the Social Security Retirement Ages by One Year

Current plans are to increase the Social Security retirement age from 65 to 67 by 2027. To judge the effect of such a change on workers with pension plans like the one in our firm, we simulate the effect of increasing the normal retirement age from 65 to 66 and the early retirement age from 62 to 63. The results are in table 7.4 and in figure 7.10. Again, the effect on the retirement rates of persons in our firm is small. This is true even though the effect on the annual retirement rates of 62- and 65-year-olds is substantial. The retirement rate of 62-year-olds is reduced from 33.9 to 25.2 percent. The rate at 65 is reduced from 28.6 to 25.1. But only a few workers remain in the firm to be affected by these changes.

Table 7.3 Simulation: Increase of Social Security Early Retirement Reduction Factor

	Retirement Rates			Cumulative Rates		
Age	Base	Simulation	Difference	Base	Simulation	Difference
50	.057	.057	.000	.057	.057	.000
51	.052	.052	.000	.105	.106	.001
52	.046	.046	.000	.146	.146	.000
53	.031	.031	.000	.173	.173	.000
54	.020	.020	.000	.190	.190	.000
55	.119	.119	.000	.286	.286	.000
56	.129	.129	.000	.378	.379	.001
57	.160	.160	.000	.478	.478	.000
58	.156	.156	.000	.560	.559	−.001
59	.194	.193	−.001	.645	.645	.000
60	.207	.207	.000	.719	.718	−.001
61	.247	.247	.000	.788	.788	.000
62	.339	.290	−.049	.860	.849	−.011
63	.365	.328	−.037	.911	.899	−.012
64	.385	.371	−.014	.945	.936	−.009
65	.286	.286	.000	.961	.955	−.006
66	.306	.306	.000	.973	.968	−.005

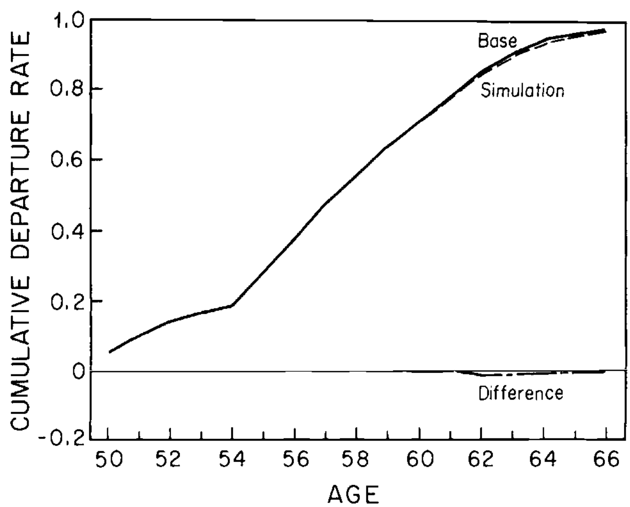

Fig. 7.9 Simulation: increase Social Security early retirement reduction factor

Table 7.4 Simulation: Increase the Social Security Retirement Age by One Year

	Retirement Rates			Cumulative Rates		
Age	Base	Simulation	Difference	Base	Simulation	Difference
50	.057	.057	.000	.057	.057	.000
51	.052	.052	.000	.105	.105	.000
52	.046	.045	−.001	.146	.146	.000
53	.031	.031	.000	.173	.172	−.001
54	.020	.020	.000	.190	.189	−.001
55	.119	.119	.000	.286	.285	−.001
56	.129	.129	.000	.378	.378	.000
57	.160	.159	−.001	.478	.477	−.001
58	.156	.155	−.001	.560	.558	−.002
59	.194	.192	−.002	.645	.643	−.002
60	.207	.206	−.001	.719	.716	−.003
61	.247	.246	−.001	.788	.786	−.002
62	.339	.252	−.087	.860	.840	−.020
63	.365	.355	−.010	.911	.897	−.014
64	.385	.369	−.016	.945	.935	−.010
65	.286	.251	−.035	.961	.951	−.010
66	.306	.306	.000	.973	.966	−.007

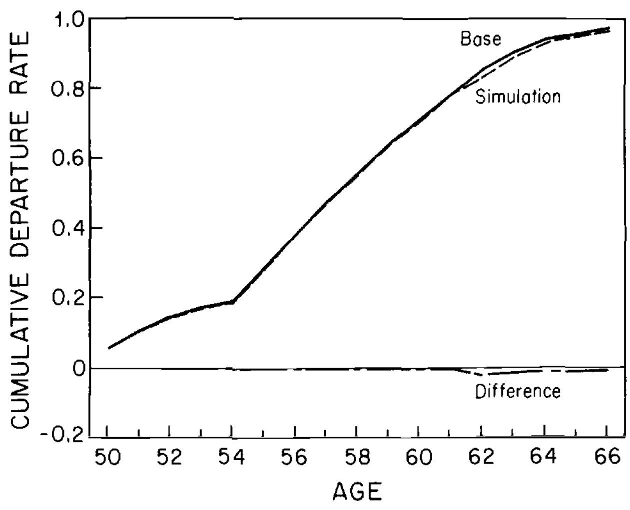

Fig. 7.10 Simulation: increase Social Security retirement ages by one year

7.3.4 Increase Social Security Retirement Ages by One Year and Start the Social Security Offset at 66

If the Social Security retirement age were increased to 66, the firm might be expected to begin the Social Security offset at 66 instead of 65. Thus, we have simulated the effect of increasing the Social Security retirement ages by one year *and* beginning the Social Security offset to the firm pension benefits at 66 instead of 65. The result is reported in table 7.5 and shown graphically in figure 7.11. Increasing the Social Security retirement ages reduced retirement rates by a small amount, as shown in table 7.4. But even these small effects effects would essentially be counteracted if the firm were to respond by delaying the imposition of the Social Security offset. For example, increasing the Social Security retirement ages reduced the retirement rate at age 62 by .087; the reduction is only .049 if the Social Security action is accompanied by the firm response that we have simulated.

7.4 Summary and Concluding Comments

The option value model developed in Stock and Wise (1988) has been used to simulate the effects on retirement of changes in a firm's pension plan and of changes in Social Security rules. Several important conclusions are supported by the analysis.

Table 7.5 **Simulation: Increase Social Security Retirement Ages by One Year *and* Start the Social Security Offset at 66**

	Retirement Rates			Cumulative Rates		
Age	Base	Simulation	Difference	Base	Simulation	Difference
50	.057	.057	.000	.057	.057	.000
51	.052	.052	.000	.105	.105	.000
52	.046	.046	.000	.146	.146	.000
53	.031	.031	.000	.173	.173	.000
54	.020	.020	.000	.190	.189	−.001
55	.119	.120	.001	.286	.287	.001
56	.129	.131	.002	.378	.380	.002
57	.160	.160	.000	.478	.479	.001
58	.156	.155	−.001	.560	.560	.000
59	.194	.192	−.002	.645	.644	−.001
60	.207	.206	−.001	.719	.718	−.001
61	.247	.246	−.001	.788	.787	−.001
62	.339	.290	−.049	.860	.849	−.011
63	.365	.370	.005	.911	.905	−.006
64	.385	.369	−.016	.945	.940	−.005
65	.286	.295	.009	.961	.958	−.003
66	.306	.265	−.041	.973	.969	−.004

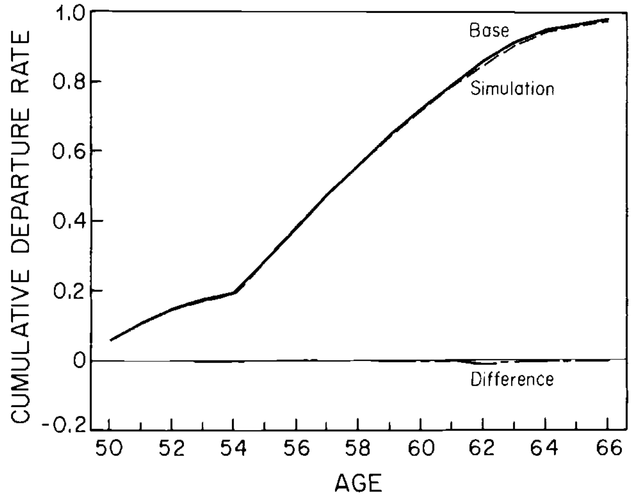

Fig. 7.11 Simulation: increase Social Security retirement ages by one year and start the Social Security offset at 66

- The provisions of the firm's pension plan have a much greater effect than Social Security regulations on the retirement decisions of the firm's employees.
- Increasing the firm's early retirement age from 55 to 60, for example, would reduce by almost 35 percent, from .645 to .422, the fraction of employees that is retired by age 60.
- The effect of changes in Social Security rules, on the other hand, would be small. Raising the Social Security retirement ages by one year, for example, has very little effect on employee retirement rates. The proportion retired by age 62 is reduced by only about 3 percent.
- Changes in Social Security provisions that would otherwise encourage workers to continue working can easily be offset by countervailing changes in the provisions of the firm's pension plan. Firm responses, like delaying the Social Security offset to correspond to a later Social Security retirement age, may simply be a logical revision of current firm plan provisions.

Thus, in considering the effect of changes in Social Security rules, like the retirement age, it is important to understand the implications of private pension plan provisions. In particular, if the effect on retirement decisions of changes in Social Security rules is to be predicted, the potential response of firms to the changes cannot be ignored.

Although the analysis is based on the retirement experience in a single large firm, the firm's pension plan is typical of defined benefit plans. Approximately 75 percent of the employees who are covered by a firm pension have defined benefit plans. Thus, the results suggest that pension plans in general have had a very substantial effect on the labor force participation rates of older workers.

In addition to the simulations, the paper describes the option value model of retirement. Comparisons of actual versus predicted retirement rates demonstrate that the model predicts complicated retirement patterns with considerable precision. That the model fits observed data well increases our confidence in the simulated results.

Notes

1. The criterion that they be employed three years facilitates the forecasting of future wage earnings on an individual basis. We plan in later work to consider other employee groups.

2. For convenience, the graphs assume a 5 percent real discount rate and zero inflation. In the empirical model that is estimated, the discount rate is estimated, and the inflation rate is assumed to be 5 percent.

3. Departure from the firm would be a more accurate description than retirement because for some employees the alternative to continued employment at the firm is likely to be another job rather than retirement.

4. Full details of the plan provisions are presented in Kotlikoff and Wise (1987).

5. Antecedents for the model begin with Lazear and Moore (1988), who argue that the option value of postponing retirement is the appropriate variable to enter in a regression equation explaining retirement. Indeed, it was their work, and analysis of military retirement rates by Phillips and Wise (1987), that motivated us to pursue this approach. Our model is also close in spirit to the much more complicated dynamic programming model of Rust (1989). A dynamic programming model of employment behavior has also been proposed by Berkovec and Stern (1988).

6. The estimates based on several years are very close to those reported here. Implementation using two or more consecutive years is only slightly more complicated than the exposition here, with $\nu_s = \nu_{s-1} + \epsilon_s$, ϵ_s i.i.d. $N(0, \sigma_\epsilon^2)$, ν_t i.i.d. $N(0, \sigma_\nu^2)$, where ν_t and ϵ_s, $s = t + 1, \ldots, S$ are independent. The covariance between ν_τ and $\nu_{\tau+1}$ is $\text{var}(\nu_\tau)$, and the variance of ν_τ for $\tau \geq t$ is $\sigma_\nu^2 + (\tau - t)\sigma_\epsilon^2$. (See Stock and Wise 1988.)

7. The estimates were obtained by maximum likelihood, using 1,500 observations. For more detail, see Stock and Wise (1988).

8. Further details on the model fit are presented in Stock and Wise (1988).

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Comment Edward P. Lazear

This is a very good paper. The model is sound, the estimates are reasonable, and the results are enlightening. Of course, every discussant must find some

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things to point out, and I have managed to collect a few; but, before doing that, I would like to start with a more general discussion of the option value approach that is used in this paper to model retirement.

The primary virtue of the option value approach that was introduced in Lazear and Moore (1988) is that it recognizes that turnover at a point in time depends on future considerations as well as current ones. A standard spot market labor supply analysis cannot take into account the effect of work today on future pension accumulation without a great deal of modification. Ignoring these life-cycle considerations leads to grossly inappropriate conclusions. In order to see this, consider an example from the U.S. military. The armed forces have pensions that cliff vest at twenty years of service. Workers who leave the service at any time before twenty years receive nothing, and those who leave at twenty years or after receive a significant pension. This means that the pension value as a function of years of service is as shown in figure 7C.1. (The function drawn in figure 7C.1 assumes for simplicity that soldiers are not permitted to stay beyond twenty years of service.)

Figure 7C.1 implies that pension accruals defined as

$$V(t) \equiv P(t) - P(t - 1)$$

have exactly the same shape as the pension value. That is, accruals are zero until year 20, and then in year 20 the full pension is accrued. Consider the distribution of turnover within the military. It is likely to look something like figure 7C.2.

Suppose that we took the individuals who left the military at some point before the twentieth year of service. Suppose further that we hypothesize that pensions affect turnover in the military because of the extreme cliff-vesting nature of the pension accrual formula. The dependent variable would be turnover rates, whereas the independent variable might be the pension value

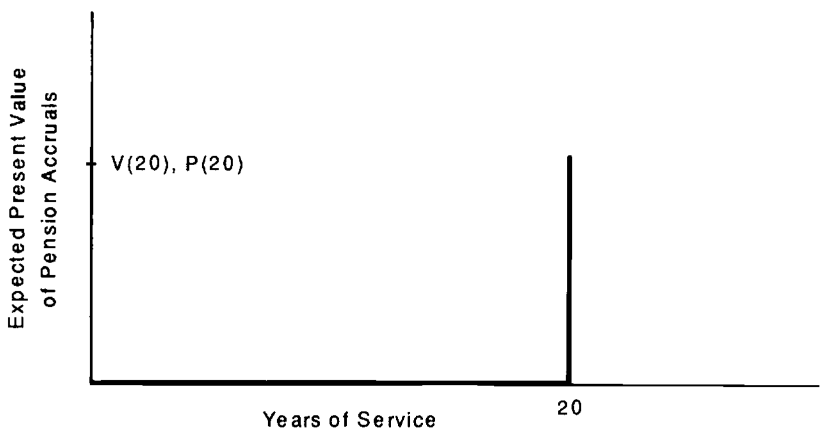

Fig. 7C.1

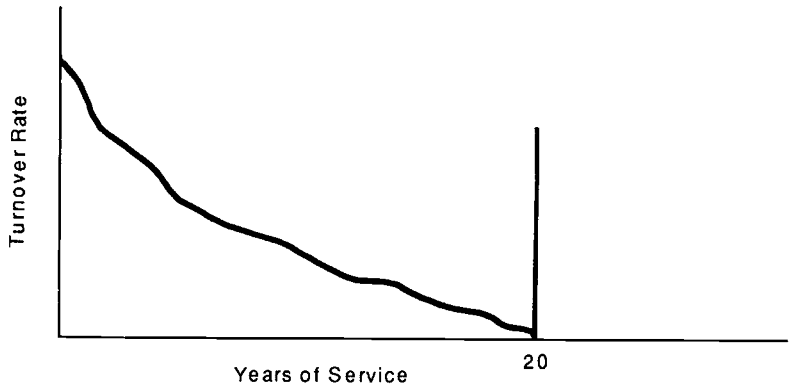

Fig. 7C.2

itself as a function of years of service or the accrual in a particular year as a function of years of service. But for years 0–19, both $P(t)$ and $V(t)$ are zero and do not vary over those nineteen years. The turnover rate, on the other hand, declines for the most part throughout the period. Thus, a regression of turnover rates on either version of an independent variable would not yield the conclusion that pensions affect turnover. Yet merely eyeballing the graphs in figure 7C.1 and figure 7C.2 makes clear that virtually no soldiers leave in the eighteenth and nineteenth years of service because hanging on for another couple of years will result in a very large pension value.

The reason that we are led astray is that the measure of pension accrual is inappropriate. It takes as relevant the change in pension amount associated with a given year of service, without being forward looking. What is being ignored is that serving, say, the eighteenth year gives the soldier the option to retire in the nineteenth year and take the pension associated with nineteen years of service or to go on to serve the twentieth year and to take the pension associated with the twentieth year. Thus, the relevant variable for pension accrual should be

$$V^*(t) \equiv M(t) - [P(t - 1)](1 - r),$$

where r is the discount rate and

$$M(t) \equiv \max\{P(t), M(t + 1)/1 + r\}$$

is defined recursively with $M(20) = P(20)$.

The definition of $V^*(t)$ takes into account that the individual need not accept the pension associated with year t but instead can serve additional years and enjoy the pension associated with longer years of service. In the case of the military, the function $V^*(t)$ is shown in figure 7C.3. A regression of turnover rates against $V^*(t)$ for soldiers who leave at some time between zero and

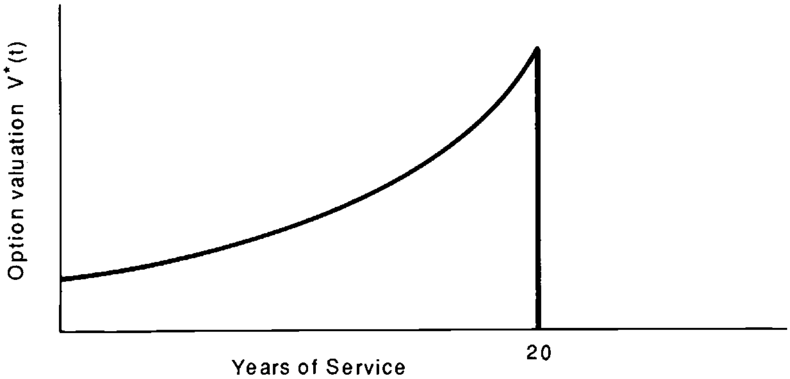

Fig. 7C.3

nineteen years will give an excellent fit because $V^*(t)$ takes into account that work in the eighteenth year is valuable by bringing the worker close to work during the twentieth year.

This approach has major advantages over other labor supply models that are designed to deal with retirement. The most common alternative is the work-leisure analysis with a kinked budget constraint. The work-leisure model is fine as far as it goes, but it falls short in a number of dimensions. First, it cannot address the timing of work over the life cycle. At best it tells us that the worker will take, say, twenty years of leisure, total; but it does not speak to the issue of when those years will be taken. Second, it is not easily adapted to changes in the pension formula. Each time there is a small change, the analysis must be completely reworked, and budget constraints must be redrawn. The shape of the $P(t)$ function in no way alters the option value analysis. Of course it will change the values associated with $V^*(t)$, but nothing need be done beyond that. Third, it is quite difficult to incorporate uncertainty into the work-leisure approach, and trivial to do so in the option value approach. All that is necessary is that the pension values are weighted by either exogenous or endogenous probabilities of continued work offers in the relevant years. Fourth, the work-leisure approach cannot deal with changes from one job to another. Workers frequently retire in their mid-50s and pick up secondary jobs. Part of those movements may be pension induced, but they are virtually impossible to analyze within the work-leisure context. A change in the alternative use of time must be parameterized as a change in tastes, which is extremely awkward. In the option value approach, one merely compares the value of working here with the alternative use of time, which is a straightforward calculation.

A second alternative model is myopic life-cycle labor supply. The worker is assumed to choose work and leisure over the life cycle, taking the age/wage relation as exogenous and given. Taken to the extreme, the model would imply that workers should have low participation in the military during years 0–19 and high participation in year 20. Of course that makes no sense since one cannot work the twentieth year without having already worked years 1–19. So a myopic model does not build in the forward-looking aspect of the compensation profile.

A third approach is to solve a dynamic programming problem in stochastic environments. This is most closely related to the option value approach but is computationally much more difficult. It essentially evaluates each potential work-leisure decision and selects the best for each worker over the range of possibilities. The option value approach is merely a simplification of this, recognizing that the relation of one value to another has to bear a particular form and that, once retirement in year T_0 is dominated by retirement in year T_1, it is unnecessary to consider year T_0 again.

Still, there is a significant body of literature where retirement behavior is estimated in a spot labor supply or kinked budget constraint work-leisure model. It is interesting to compare how the Stock-Wise estimates do, relative to some of these others. Unfortunately, Stock and Wise do not do as much comparison as I would like to see done, but they do make a convincing case that their model fits their data extremely well, and it is difficult to imagine that other models would come close to this kind of fit. Some of their claims, however, are a bit too strong. First, the authors claim that their model does well because it beats using only four variables a model that contains seventeen age dummies but ignores future income. Perhaps, but the option value approach is not the only way to take economic variables into account. A better comparison is between the option value approach and the kinked budget constraint model, on the same data, because the kinked budget constraint model also builds in these economic effects. Since the authors emphasize the point that the option value model fits the jumps very well, the kinked budget constraint model (which also fits jumps) is probably the best benchmark.

In the same vein, option values are sensitive to changes in pensions, early retirement values, and vesting provisions, and this of course is the main strength of the option value approach. But the work-leisure kinked budget constraint model is also sensitive to these changes. It would be useful to see which is more volatile and which fits the data the best.

Partial retirement and reentry into the labor market were not handled in a clean way in this paper. Partial retirement can be incorporated into the reservation value, but then income and benefits need to be defined as net of what is available on the other job. This is especially problematic if the other job has a pension or upward-sloping age earnings profile itself. Under these circumstances, the worker might want to retire early enough to start the other job so that vesting can be achieved there.

It was unclear how the authors allowed illness to affect income in the model. The random-walk error structure allows illness to have permanent effects, but some mean reversion process may be more appropriate in the health context.

The most serious empirical disappointment is that the model misses badly on retirement at age 65. This made me wonder whether there was some mandatory retirement constraint either explicit or implicit associated with the pension plan. Also, timing is particularly important here because old workers enjoyed a wealth increase as a result of changes in ADEA legislation that permitted them to work beyond age 65.

While the descriptive statistics that Stock and Wise provide are compelling, perhaps the kappa measure of prediction should be used to get a better feel for how well the model actually does predict retirement ages. Finally, the authors talk about policy changes in Social Security, but they treat the Social Security changes as having no effects on the rest of the compensation profile. However, previous work has taught us that firms and workers will optimize against the Social Security and unemployment compensation system in a way that makes both sides better off. This means that the pension plan and the rest of the compensation profile will switch. For example, if Social Security age of entitlement rises from age 65 to age 67, then it will be optimal to induce most workers to retire at age 67, and the pension plan should be adjusted to bring that about. This could be accomplished by offset provisions that already build some of those changes in or by direct changes in the pension accrual formula.

On the whole, this paper is one of the most successful empirical pieces that I have seen in the retirement area, and I hope that more work of its type will follow.

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