Volume Title: Themes in the Economics of Aging

Volume Author/Editor: David A. Wise, editor

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-90284-6

Volume URL: http://www.nber.org/books/wise01-1

Publication Date: January 2001

Chapter Title: Incentive Effects of Social Security under an Uncertain Disability Option

Chapter Author: Axel H. Boersch-Supan

Chapter URL: http://www.nber.org/chapters/c10331

Chapter pages in book: (p. 281 - 310)

9

Incentive Effects of Social Security under an Uncertain Disability Option

Axel Börsch-Supan

9.1 Introduction

In most industrialized countries, old-age labor force participation has declined dramatically during the last decades. Together with population aging, this puts the social security systems of the industrialized countries under a double threat: Retirees receive pensions for a longer time while there are less workers per retiree to shoulder the financial burden of the pension system. The decline of old-age labor force participation has therefore turned attention to the incentive effects of social security systems: Is a significant part of the threat homemade because pension systems provide overly strong incentives to retire early? This "pull" view—that labor supply has declined because early retirement provisions pull old workers out of employment—is in contrast to the "push" view—that a secularly declining demand for labor has created unemployment, one form of which is to push older workers into early retirement.

The pull view is prominently put forward in a recent volume edited by Gruber and Wise (1999). The authors from eleven countries argue that the declining old-age labor force is strongly correlated with the incentives created by generous early retirement provisions. Formal econometric analyses (e.g., Stock and Wise 1990 for the United States; Meghir and Whitehouse 1997 for the United Kingdom; Börsch-Supan 1992, 2000 for

Axel Börsch-Supan is professor of economics and director of the Institute of Economics and Statistics at the University of Mannheim, and a research associate of the National Bureau of Economic Research.

Financial support was provided by the Deutsche Forschungsgemeinschaft through the Sonderforschungsbereich 504 and by the National Institute on Aging through the National Bureau of Economic Research. Comments by Anne Case and David Cutler and, in particular, by Daniel McFadden were greatly appreciated.

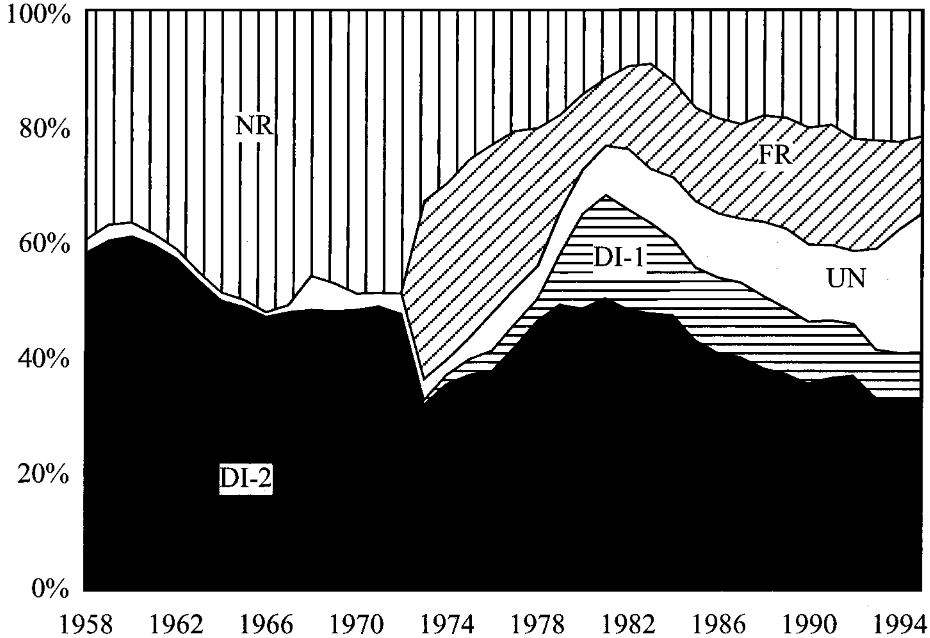

Fig. 9.1 Pathways to retirement

Notes: The figure shows the share of pathways by year. The shaded areas are NR (normal retirement); FR (flexible retirement [only after the 1972 reform]); UN (early retirement because of unemployment); DI-1 (early retirement because of onset of disability after age sixty [only after the 1972 reform]); DI-2 (early retirement because of onset of disability before age sixty).

Source: Verband deutscher Rentenversicherungsträger (1997)

Germany) find strongly significant coefficients of variables measuring the incentive effects of pension rules (e.g., the option value to postpone retirement).

Incentive effects of pension rules are usually estimated under the assumption that the institutional environment provides a single optimal pathway for retirement. This optimal pathway then defines present values of retirement income at any retirement age, or an option value of postponing retirement at any prospective retirement age. However, most countries provide competing pathways that include several early retirement options in addition to normal retirement, typically at age sixty-five.

Jacobs et al. (1991) have stressed the variety of these pathway options across Europe. Figure 9.1 shows how important these different exit routes or pathways are in Germany. It is particularly impressive that early retirement due to a disability before age sixty (denoted by DI-2) was the most common pathway in most of the years 1958–94, while “normal” retirement (denoted by NR) has a share of less than 20 percent since the mid-1970s.

Early retirement due to unemployment (denoted by UN) increased steeply in the early 1990s and accounted for roughly another 20 percent of labor market exits. Complicating this picture even more, the exit routes depicted in figure 9.1 are frequently preceded by preretirement schemes. These schemes are industry- or company-specific and are popular not only in Germany but also in many other European countries.

When measuring incentive effects, one encounters two distinct problems associated with this multitude of exit routes. First, early retirement options such as the special provisions for disabled and unemployed workers can effectively be strategic variables for the employer and the employee. Employers may have an incentive to let the social security system pay for the costs of restructuring the workforce, whereas employees may have an incentive to enjoy leisure early at the expense of the contributors to the social security system. As a result, constructs of incentive effects that rely on indicators for the availability of a certain pathway are endogenous. A prime example of such an indicator is the reported health status, often measured as the extent of disability in percent of full work ability. This is frequently the legal prerequisite for early retirement and can be manipulated at least to some extent, as has been controversially discussed by Bound (1989) and Parsons (1991). The complicated interaction between health and the eligibility for disability benefits has been documented by a working group led by John Rust (Benitez et al. 1998) as a prerequisite for a structural estimation of incentive effects due to disability benefits, improving on the large U.S. literature on this topic.

A second technical problem associated with the multitude of exit routes is that the choice of a specific pathway to retirement is made when it is not clear whether certain options are actually relevant for the individual contemplating early retirement. Again, disability is the prime example: Even if the reported health status has not been manipulated, econometricians face the problem that the outcome of the screening process for eligibility is far from certain ex ante. If econometricians specify the option set too generously, they exaggerate the incentives at work and thus underestimate the coefficient of the incentive variable. In turn, incentive effects may be overestimated—and thus the pull view of early retirement—if the option set is too restrictive.

This paper shows that ignoring the uncertainty and endogeneity of the relevant institutional setting (i.e., the available pathways) can severely bias the estimates of incentive effects. The paper focuses on the disability option that provides particularly strong incentives. It proposes several estimates to bound the "true" incentive effects of social security on early retirement in the face of uncertainty, and it uses an approximate two-stage procedure to tackle the endogeneity problem.

Section 9.2 provides the institutional background of the German pension system and the early retirement incentives it creates. Section 9.3 introduces the data, a sample of German workers aged fifty-five to seventy drawn from the German Socio-Economic Panel, and describes patterns of retirement, disability and health in the sample. Section 9.4 presents estimation results for several specifications aimed at correcting for uncertainty and endogeneity of the disability benefit eligibility. Section 9.5 concludes and draws policy recommendations.

9.2 Incentives Created by the German Public Pension System

The German public pension system is particularly well suited to a microeconometric study of incentive effects on labor force participation because it is almost universal and we do not need to account for a variety of firm pension plans that create their own incentive effects but are usually not well captured in survey data (Börsch-Supan and Schnabel 1998). The homogeneity arises for two reasons. First, the German public pension system is mandatory for every worker except for the self-employed and those with very small labor incomes. Because almost all German workers have been dependently employed at least at some point in their working careers, almost every worker has a claim on a public pension. Second, the system has a very high replacement rate, generating net retirement incomes that are currently about 70 percent of preretirement net earnings for a worker with a forty-five-year earnings history and average lifetime earnings. This is substantially higher than the corresponding U.S. net replacement rate of about 53 percent. In addition, the system provides relatively generous survivor benefits that constitute a substantial proportion of the total pension liability. As a result, social security income represents about 80 percent of household income for households headed by persons aged sixty-five and over; the remainder is divided about equally among firm pensions, asset income, and private transfers.

A detailed description of the German public pension system is given by Börsch-Supan and Schnabel (1999). In the sequel, we only summarize the features that create incentives to retire early. Until 1972, retirement was mandatory at age sixty-five. Early retirement was possible and frequent through the disability pathway (see fig. 9.1). With the landmark 1972 pension reform, several early retirement options were introduced. Figure 9.1 shows that early retirement almost instantaneously substituted for a considerable portion of disability benefits—a fairly strong indication that disability status was not related only to health. The pension system established in 1972 now provides *old-age pensions* for workers aged sixty and older, and, for workers below age sixty, *disability benefits,* which are converted to old-age pensions at age sixty-five at the latest.

The main feature of the *old-age pensions* is flexible retirement from age sixty-three for workers with long service histories. In addition, retirement at age sixty is possible for women, unemployed workers, and workers who cannot be employed appropriately for health or labor market reasons. It is noteworthy that these features were introduced by the 1972 reform as social achievements *before* unemployment began to rise in the mid-1970s. Only later was it realized that they helped to keep the unemployment rate down. Twenty years after the introduction of the various early retirement options, the 1992 pension reform is attempting to close some of those options. However, the effects are irrelevant for the current sample because they will be visible only after the year 2004.

Old-age pension benefits are computed on a lifetime contribution basis. They are the product of four elements: (1) the employee's relative wage position, averaged over the entire earnings history, (2) the number of years of service life, (3) several adjustment factors, and (4) the average pension level. The first three factors make up the "personal pension base," which is calculated when one is entering retirement. Old-age pensions are proportional to length of service life, a specific feature of the German pension system. The fourth factor determines the income distribution between workers and pensioners in general and is adjusted annually to net wages. Thus, productivity gains are transferred each year to all pensioners, not only to new entrants. Due to a generous exemption, social security benefits are tax free unless income from other sources is high.

Early retirement incentives are created by the (lack of) adjustment factors. Before the 1992 pension reform, there was no explicit adjustment of benefits when a worker retired earlier than age sixty-five, except for a bonus when retirement was postponed from ages sixty-five or sixty-six by one year. Nevertheless, because benefits are proportional to the years of service, a worker with fewer years of service would get lower benefits even before the bonus. With a constant income profile and forty years of service, each year of earlier retirement decreased pension benefits by 2.5 percent. This is substantially less than the actuarial adjustment, which increases from about 5.5 percent for postponing retirement one year at age sixty to 8 percent for postponing retirement one year at age sixty-five. The 1992 pension reform will gradually change this by introducing retirement age–specific adjustment factors to the benefit formula. However, they will remain about 2 percent below those required for actuarial fairness. Figure 9.2 displays actuarial adjustments as well as those under the current (i.e., relevant for our working sample) and future institutional settings.

Disability pensions before reaching age sixty are particularly generous. First, the service life used in a similar computation as for old-age pensions is extended by the time between the onset of the disability and age sixty, albeit at a reduced earnings base at two-thirds of the last earnings. Second, disability benefits are not actuarially adjusted, even after the 1992 reform, but are computed as if the worker had retired at age sixty. Disability pensions after age sixty are computed like old-age pensions, but without actuarial adjustments.

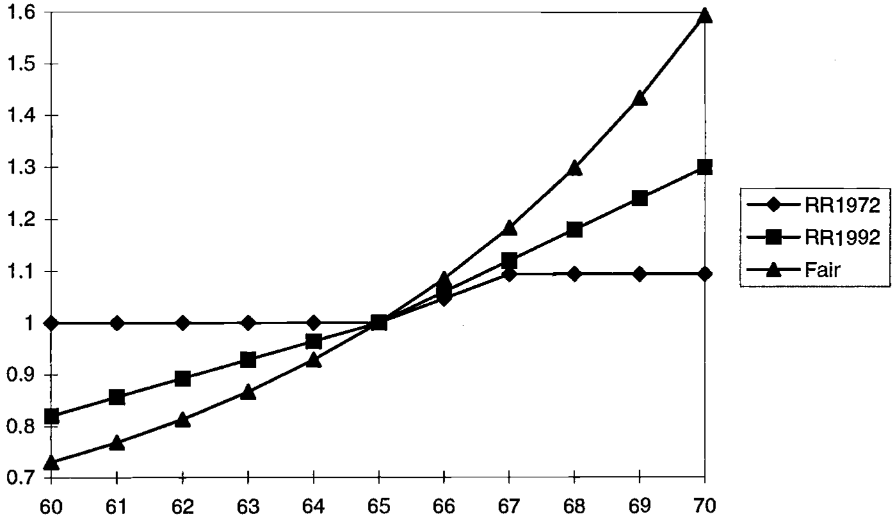

Fig. 9.2 Adjustment of retirement benefits to retirement age
Source: Börsch-Supan and Schnabel 1998.
Notes: RR1972 denotes the adjustment factors introduced by the 1972 pension reform. RR1992 symbolizes the adjustments that will be phased in by the 1992 pension reform. "Fair" refers to actuarially fair adjustment factors.

The key statistic needed to measure the early retirement incentives exerted by the actuarially unfair adjustment factors is the change in social security wealth. If social security wealth declines because the increase in the annual pension is not large enough to offset the shorter time of pension receipt, workers have a financial incentive to retire earlier. We define social security wealth as the expected present discounted value of benefits minus applicable contributions. Seen from the perspective of a worker who is S years old and plans to retire at age R, social security wealth (SSW) is

$$\mathrm{SSW}_S(R) = \left(\sum_{t=R}^{\infty} \mathrm{YRET}_t(R) \cdot a_t \cdot \delta^{t-S}\right) - \left(\sum_{t=S}^{R-1} c \cdot \mathrm{YLAB}_t \cdot a_t \cdot \delta^{t-S}\right),$$

with

SSW	present discounted value of retirement benefits (= social security wealth),
S	planning age,
R	retirement age,
YLAB_t	labor income at age t,
$\mathrm{YPEN}_t(R)$	pension income at age t for retirement at age R,
c_t	contribution rate to pension system at age t,

a_t probability to survive at least until age t given survival until age S, and

δ discount factor $= 1/(1 + r)$.

The accrual rate of social security wealth between age $t - 1$ and t is

$$\mathrm{ACCR}_S(t) = \frac{[\mathrm{SSW}_S(t) - \mathrm{SSW}_S(t - 1)]}{\mathrm{SSW}_S(t - 1)}.$$

A negative accrual can be interpreted as a tax on further labor force participation. It is particularly handy to express this as an implicit tax rate: the ratio of the (negative) social security wealth accrual to the net wages ($\mathrm{YLAB}^{\mathrm{NET}}$) that workers would earn if they would postpone retirement by one year

$$\mathrm{TAXR}_S(t) = \frac{-[\mathrm{SSW}_S(t) - \mathrm{SSW}_S(t - 1)]}{\mathrm{YLAB}_t^{\mathrm{NET}}}.$$

Figure 9.3 shows that the early retirement incentives created by the old-age pension formula in Germany are strong. We will see below that the incentives created by disability benefits are even stronger. The accrual function (panel A) has three distinctive kink points. The first kink occurs at age sixty, the earliest retirement age into the public pension system with-

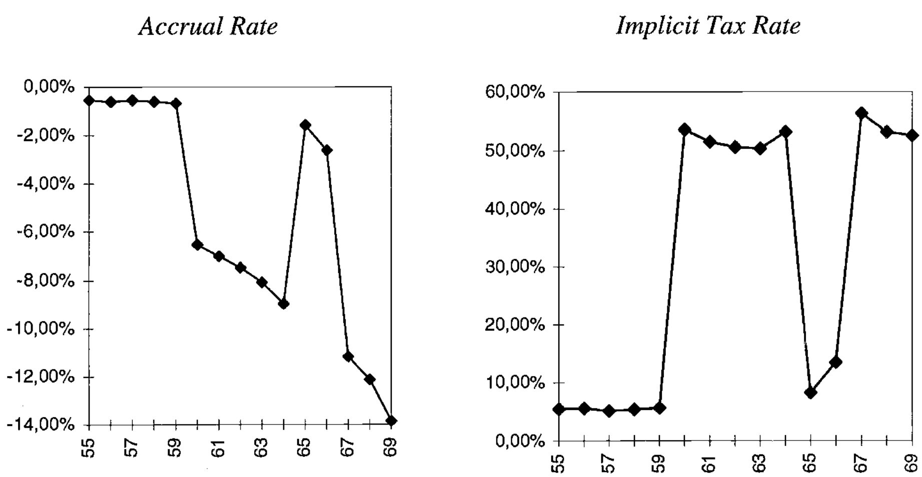

Fig. 9.3 Loss in social security wealth when postponing retirement (1972 rules, old-age pensions only): (*A*) accrual rate, (*B*) implicit tax rate

Source: Börsch-Supan and Schnabel 1998

Note: See text for definition of accrual rate $ACCR_S(t)$ and implicit tax rate $TAXR_S(t)$ for $S =$ 55 and $t = 55 \ldots 69$.

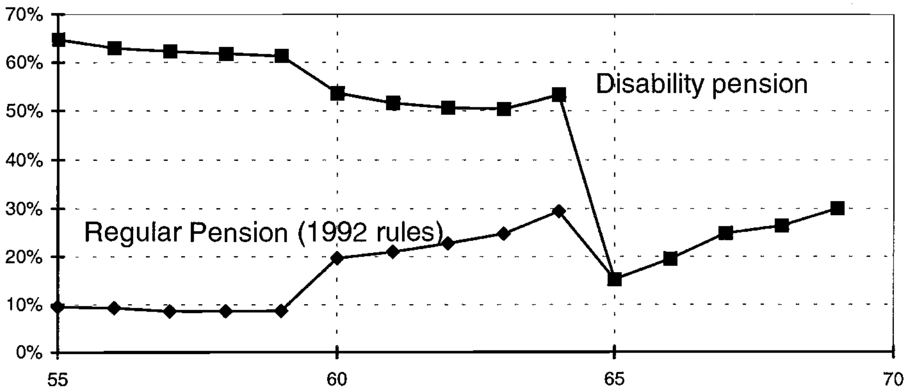

Fig. 9.4 Implicit tax on postponing retirement, disability case
Source: Börsch-Supan and Schnabel 1998.
Note: See text for definition of implicit tax rate $TAXR_S(t)$.

out disability status. Two other kinks are generated by the bonus for postponing retirement at ages sixty-five and sixty-six, interrupting the steady increase in negative pension wealth accrual.

The lack of actuarial fairness of the old-age pension system creates a negative accrual of pension wealth during the early retirement window at a rate reaching −9 percent when retirement is postponed from age sixty-four to sixty-five. In 1995, this was a loss of about 22,000 deutsche mark (US$10,500 at purchasing power parity) for the average worker. Expressed as a percentage of annual labor income, the loss corresponds to a "tax" that exceeds 50 percent.

The 1992 pension reform will moderate but not abolish this incentive effect. After 2004, when the 1992 reform will have been fully phased in, the negative accrual rate will reach −5 percent, corresponding to an implicit tax rate of almost 30 percent when retirement is postponed by one year at age sixty-four.

Disability benefits create even stronger labor supply disincentives. The resulting implicit tax rates for postponing retirement are very large (see figure 9.4). They are likely to create strong incentives to manipulate disability eligibility: If there is a chance to claim disability, not taking it corresponds to a 60 percent implicit tax on earnings.

9.3 Data and Descriptive Statistics

How do these incentives affect actual retirement behavior? We use the 1984–96 waves of the German Socio-Economic Panel (GSOEP) to tackle this question. The GSOEP is an annual panel study of some 6,000 households and some 15,000 individuals. Its design corresponds closely to that of the U.S. Panel Study of Income Dynamics (PSID). Response rates and panel mortality are also comparable to those for the PSID. The GSOEP data provide a detailed account of income and employment status. The data are used extensively in Germany, and the increasing interest in the United States prompted the construction of an English-language user file available from Richard Burkhauser and his associates at Syracuse University. Burkhauser (1991) reports on the usefulness of the German panel data and provides English-language code books for the internationally accessible GSOEP version. Since 1990, the West German panel has been augmented by an East German sample.

For this paper, however, I use only West German workers because preretirement is frequent in East Germany and I lack the necessary company-specific information to describe the incentives appropriately. My working sample consists of all West Germans who are aged fifty-five to seventy years and have at least one spell of employment in this window in order to reconstruct an earning history. This working sample includes 1,610 individuals. We construct an unbalanced panel of these individuals with 8,577 observations and an average observation time of 5.3 years. A few sample persons are right-truncated with respect to retirement (i.e., they are employed throughout the entire window period) but most individuals retire before the age of seventy. Of the 1987 individuals, 666 have no transitions, 643 have a single transition from employment to retirement, and 301 individuals have more complex histories with at least one reverse transition. Thirty-five percent are female, and the most common retirement age is sixty.

I define a worker to be retired when the self-reported employment status is "out of labor force." This includes unemployed workers and workers on preretirement who may not receive public pensions but may receive other support ranging from unemployment benefits to severance pay. Figure 9.5 depicts the percentage of retired persons in my working sample and shows three distinct jumps: the largest at age sixty, and two smaller ones at ages sixty-three and sixty-five, corresponding to the earliest ages at which eligibility to various pension types begins (see section 9.2). Very few individuals are working after age sixty-five. These patterns in the working sample strongly correspond to administrative records (e.g., Verband deutscher Rentenversicherungsträger [VdR] 1997). Even before official old-age retirement begins, about 15 percent of the workers have retired. This percentage in our working sample is somewhat lower than in the administrative records, depicted in figure 9.1, indicating that the working sample underrepresents problem cases who retire very early. This reflects the middle-class bias typical for the GSOEP.

The jump at age sixty is due to three institutional features. Women with a work history of at least fifteen years may retire at age sixty; any unemployed worker may retire at age sixty if certain mild requirements are satis-

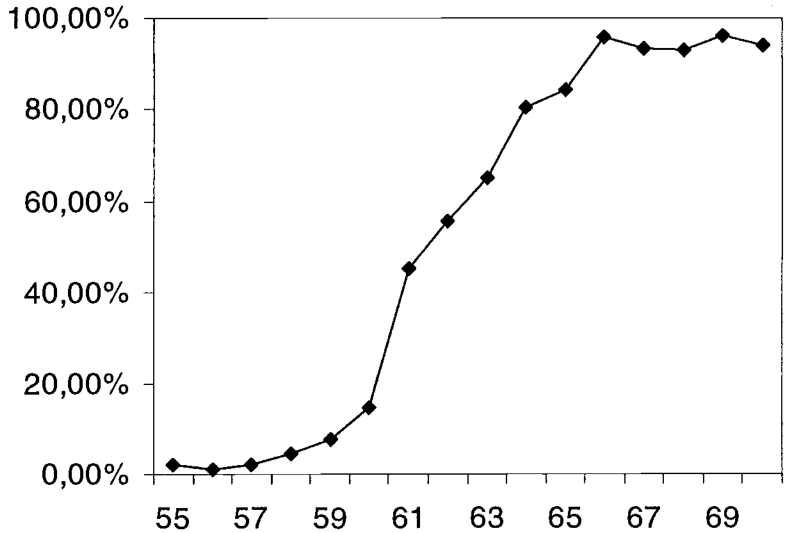

Fig. 9.5 Self-reported retirement by age
Source: German Socio-Economic Panel (GSOEP) 1984–96 and author's calculations.

fied; and, most importantly, workers who are able to claim "old-age disability" may also retire already at age sixty. This old-age disability between ages sixty-one and sixty-five has weaker health and job status requirements than "normal disability" before age sixty.

Disability is officially measured as percent of earnings capability. If this falls below 50 percent, workers after age sixty can claim a disability pension that corresponds to a normal pension, without actuarial adjustments. Indeed, the average degree of disability in the sample increases steadily until age sixty-two, when it reaches 20 percent. After age sixty-three, it increases much more slowly (see fig. 9.6).

Since it seems implausible that this sudden change is caused by a change in health status, this pattern suggests an institutional reason. It is easy to find. From age sixty-three on, all male workers can receive a normal pension, provided they have thirty-five years of work (which most male workers have). In fact, a striking finding is the weak correlation between the degree of disability and self-reported health. Figure 9.7 shows that self-reported health changes very little, and although a regression of the degree of disability on self-reported health features a significant positive correlation between bad health and disability, its R^2 is only about 3 percent. Partly, this weak correlation is due to the fact that disability status is granted not only for health-related but also for employment-related reasons. Even healthy workers are classified as disabled if there are no jobs available for their specific skills. Leniency in those regulations has changed frequently and unpredictably. They were subject not only to government

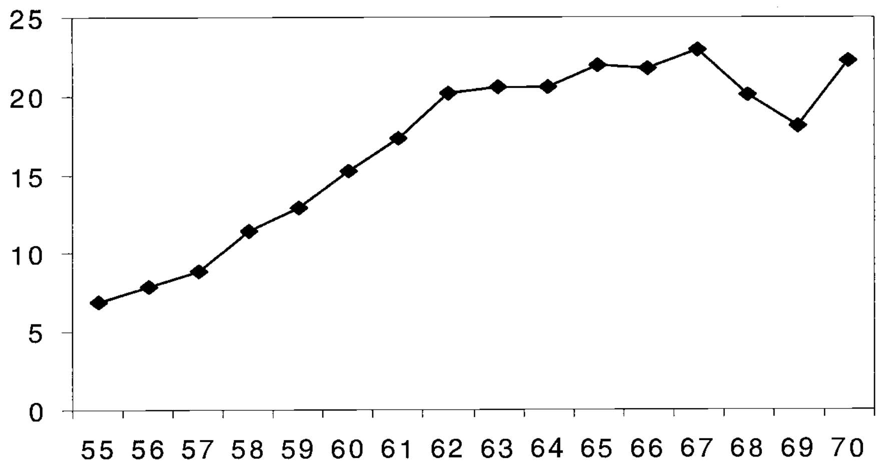

Fig. 9.6 Average degree of disability by age (percentage)
Source: GSOEP 1984–96 and author's calculations

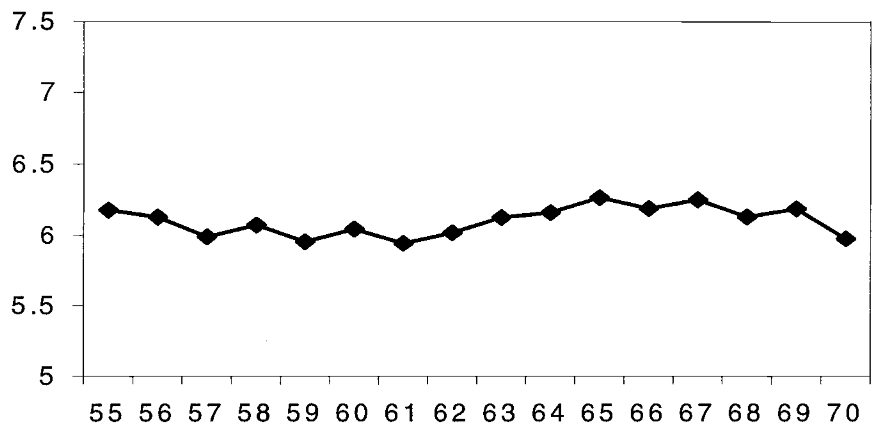

Fig. 9.7 Average self-reported health on a 0–10 scale
Source: GSOEP 1984–96 and author's calculations

policy (e.g., in order to manipulate the unemployment rate) but also to law cases (which at some point ruled, for example, that earnings tests for disabled workers were illegal).

9.4 Alternative Estimates of Incentive Effects to Retire Early

The evidence in the previous section suggests that disability is an important mechanism for early retirement. However, even in the lenient German system, disability is not granted automatically. Only 16 percent in my working sample report a disability status of 50 percent or more. In addition, the discussion at the end of the preceding section has shown that when one is planning ahead for the choice of retirement age, it is far from clear whether this exit pathway can be taken. Incentives for early retirement thus have a strong element of uncertainty, which must be built into measures of incentive effects.

I capture the economic incentives provided by the pension system using the option value to postpone retirement (Stock and Wise 1990). This value captures for each retirement age the trade-off between retiring now (resulting in a stream of retirement benefits that depends on this retirement age) and keeping all options open for some later retirement date (with associated streams of first labor, then retirement incomes for all possible later retirement ages). Consequently, the option value for a specific age is defined as the difference between the maximum attainable consumption utility if the worker postpones retirement to some later year minus the utility of consumption that the worker can afford if he or she would retire now. The definition corresponds closely to the construction of social security wealth in the preceding section.

Let $V_t(R)$ denote the expected discounted future utility at age t if the worker retires at age R. Let $R^*(t)$ denote the optimal retirement age if the worker postpones retirement past age t, i.e., $\max[V_t(R)]$ for $r > t$. With this notation, the option value is

$$\text{OPTVAL}(t) = V_t[R^*(t)] - V_t(t).$$

Since a worker is likely to retire as soon as the utility of the option to postpone retirement becomes smaller than the utility of retiring now, retirement probabilities should depend negatively on the option value.

I specify the expected utility as follows:

$$V_t(R) = \sum_{s=t}^{R-1} u(\text{YLAB}_s) \cdot a_s \cdot \delta^{s-t} + \alpha \sum_{s=R}^{\infty} u[\text{YRET}_s(R)] a_s \cdot \delta^{s-t}$$

with

YLAB_s	labor income at age s, $s = t \ldots R - 1$,
$\text{YRET}_s(R)$	expected retirement income at age s, $s > R$,
R	retirement age,
α	marginal utility of leisure, to be estimated,
a	probability to survive at least until age s, and
δ	discount factor, set at 3 percent.

To capture the utility from leisure, utility during retirement is weighted by $\alpha > 1$, where $1/\alpha$ is the marginal disutility of work. We use an estimate of $\alpha = 3.13$ that was obtained by grid search (see Börsch-Supan 2000). A dollar that must be earned by work is therefore valued at only about a third of a dollar that is given as a public transfer through the retirement system. This value is somewhat higher than estimates for the United States (Stock and Wise 1990) but not implausible for Germany with an arguably higher preference for leisure. I apply a very simple utility function by identifying consumption with income. Preliminary estimates with an isoelastic utility function, $u(Y) = Y^{\gamma}$, yield a γ coefficient that is not significantly different from 1. Finally, the discount factor δ is assumed to be 3 percent. Other discount factors in the range between 1 and 6 percent yield qualitatively similar results.

Uncertainty enters the option value through future income. For labor income, I assume it to be constant after age fifty-five. This is typical for German workers who have seniority rules that flatten out about this age. However, retirement income depends on retirement age and the rules applicable to the individual at that age. As stressed before, it is uncertain which rules will actually apply.

The common procedure in the literature is to use the retirement income according to the rules that have ex post been applied to the sample individual. This procedure is correct for fixed personal characteristics. For example, as pointed out in section 9.2, German public pension rules have a more generous retirement age for women than for men. Hence, male persons are assigned pension rules for males, and females likewise.

Similarly, the literature has typically assigned disabled individuals a pension according to the rules for disabled workers. However, as opposed to such fixed characteristics as gender, this procedure ignores both uncertainty and potential endogeneity. First, the option value approach is an ex ante (not an ex post) view of the utility of a certain retirement age. The ex ante uncertainty cannot be resolved by the econometrician by using its ex post value. Rather, one needs to use the expected value applicable at the time of decision making. Specifically, the ability to claim disability status is not certain at age fifty-five, the beginning of my decision window. The retirement income YRET in the above equation should therefore be a probability-weighted sum of the relevant pathways, in this simple case "disability" and "normal retirement."

Moreover, as stressed before, eligibility can be manipulated to some extent, and there are strong incentives to do so. Thus the probability of taking this pathway is potentially endogenous. I therefore must use an instrumental variable (IV) approach to compute fitted probabilities of the pathways "disability" and "normal retirement." This leads to four variants of the option value to postpone retirement:

- *The tough variant.* All individuals are assigned retirement incomes according to normal retirement rules.
- *The generous variant.* All individuals are assigned retirement incomes as if they could claim disability benefits.

- *The endogenous variant.* Disabled persons are assigned disability pensions, nondisabled persons normal pensions.
- *The probabilistic variant.* Individuals are assigned an expected value, where disability pensions are weighted by a probability p, and normal pensions by $(1 - p)$. Taking the endogeneity of p into account, I use three IV approaches:
  a. I use the population frequency of being disabled (15.97 percent),
  b. I regress the probability of having a degree of disability of 50 percent or higher on a cubic polynomial in age and use this fitted value as probability p, and
  c. I regress the probability of having a degree of disability of 50 percent or higher on a cubic polynomial in age, a set of branch and education dummies, plus gender and marital status, and use this fitted value as probability p.

I then insert the resulting option value into a discrete choice model with "retired" as the dependent variable, and add the usual suspects as other explanatory variables: an array of socioeconomic variables such as gender, marital status, and wealth (indicator variables of several financial and real wealth categories), and a self-assessed health measure. Obviously, I cannot use the legal disability status as a measure of health because this is potentially endogenous.

Inserting the option value in a regression-type model is much less computationally involved and more practical than the estimation procedure employed by Stock and Wise (1990), which in turn much more closely approximates the underlying dynamic programming structure (Rust and Phelan 1997; see Lumsdaine, Stock, and Wise 1992). The regression approach generates robust estimates of the average effects of the option value on retirement, although it is inferior in predicting individual choices when incentives vary widely across individuals.

I begin by using a simple logit model. Table 9.1 presents a summary, table 9.2 the full range of results.

In the "generous" specification of expected retirement income—"everybody is eligible for disability benefits"—the sign of the option value coefficient is counterintuitive. All other specifications have the expected negative sign: An increase in the option value to postpone retirement decreases the probability of being retired. The probabilistic variants are very close to each other and are bracketed by the "generous" and the "tough" variants. The first-stage R^2s in the last two specifications are 8 and 15 percent, respectively. The "endogenous" specification, however, is far outside this bracket, considerably larger and with an (apparent) very high precision as indicated by the t-statistic. The endogeneity bias produces a threefold higher estimate of the option value coefficient than the probability-weighted specifications.

Table 9.1 **Option Value Coefficients for Six Variants of Expected Retirement Income**

	Estimated Coefficient of Option Value	t-statistic
Model 1 (generous variant)	0.0053 (0.00115)	4.63
Model 2 (tough variant)	−0.0046 (0.00098)	−4.72
Model 3 (endogenous variant)	−0.0096 (0.00080)	−12.02
Model 4a (p = sample frequency)	−0.0034 (0.00122)	−2.79
Model 4b (p = age polynomial)	−0.0038 (0.00116)	−3.28
Model 4c (p = full regression)	−0.0032 (0.00114)	−2.84

Source: Author's calculations based on GSOEP working panel of men, 1984–96.
Notes: Standard errors in parentheses. See text for explanation of variants.

Table 9.2 presents the full results. A positive coefficient indicates that the corresponding explanatory variable increases the probability of retirement. In addition to the option value, health, and an array of socioeconomic variables, we include a full set of age dummies to nonparametrically capture all other unmeasured effects on the retirement decision that are systematically related to age, such as social customs. The reference category is age sixty-five.

Prediction success rates are high and vary from 88.7 to 89.3. This fit compares favorably to the baseline probability of 67.9 percent of retirees in our working sample. Except for the difference among the option value coefficients, all other coefficient estimates are fairly close to each across the six specifications.

The other economic incentives for retirement, namely the wealth variables, are only partially significant. The GSOEP data do not contain levels of wealth and provide only indicators of whether certain portfolio components—firm pension, life insurance, stock and bonds, and real estate—are present. There are many missing values, here coded as "not present." In general, presence of financial and real wealth decreases the retirement probability. This is not especially plausible for the presence of a firm pension. However, significant firm pensions are rare in Germany and usually indicate more highly valued jobs in which retirement may occur later for reasons not related to the firm pension per se.

The pattern of age dummies reflects the obvious: Older workers are more likely retired than younger ones. It is important to measure the option value with the age dummies included in order to purge its estimated

Table 9.2 **Logit Model of the Retirement Decision (parameters)**

				Probabilistic Variants		
Variable	Model 1 (generous variant)	Model 2 (tough variant)	Model 3 (endogenous variant)	Model 4a (p = sample frequency)	Model 4b (p = age polynomial)	Model 4c (p = full regression)
Option value	0.0053	−0.0046	−0.0096	−0.0034	−0.0038	−0.0032
	(4.63)	(−4.72)	(−12.02)	(−2.79)	(−3.28)	(−2.84)
Health	−0.1781	−0.1803	−0.1512	−0.1813	−0.1810	−0.1804
	(−9.83)	(−9.96)	(−8.23)	(−10.02)	(−10.01)	(−9.98)
Female	0.0995	0.0434	0.0277	0.1553	0.1416	0.1711
	(1.10)	(0.46)	(0.33)	(1.72)	(1.58)	(1.94)
Married	−0.0404	−0.0394	−0.0461	−0.0358	−0.0376	−0.0437
	(−0.41)	(−0.40)	(−0.47)	(−0.36)	(−0.38)	(−0.44)
Education	−0.6230	−0.6166	−0.5811	−0.6303	−0.6295	−0.6199
	(−4.73)	(−4.60)	(−4.23)	(−4.74)	(−4.72)	(−4.65)
Civil servant	0.4733	0.4988	0.4860	0.4691	0.4719	0.4493
	(3.29)	(3.38)	(3.22)	(3.23)	(3.24)	(3.11)
Firm pension	−2.7015	−2.7712	−2.7925	−2.7551	−2.7604	−2.7516
	(−10.15)	(−10.31)	(−10.33)	(−10.29)	(−10.31)	(−10.29)
Life insurance	−0.0997	−0.1104	−0.1496	−0.1166	−0.1154	−0.1178
	(−1.27)	(−1.40)	(−1.88)	(−1.48)	(−1.47)	(−1.50)
Stocks/bonds	0.0280	0.0089	0.0135	−0.0018	−0.0007	−0.0014
	(0.30)	(0.09)	(0.14)	(−0.02)	(−0.01)	(−0.02)
Real estate	−0.8257	−0.8019	−0.8212	−0.7984	−0.7993	−0.7961
	(−7.55)	(−7.33)	(−7.43)	(−7.31)	(−7.32)	(−7.29)
Owner occupation	0.3148	0.3214	0.3423	0.3126	0.3138	0.3102
	(3.76)	(3.84)	(4.04)	(3.74)	(3.75)	(3.71)

Age ≤ 59	−5.2324	−4.6547	−4.3121	−4.9478	−4.8577	−4.9335
	(−29.33)	(−21.32)	(−22.86)	(−23.17)	(−22.30)	(−23.00)
Age = 60	−3.4990	−3.2143	−3.0945	−3.3805	−3.3655	−3.4124
	(−17.93)	(−15.51)	(−15.60)	(−16.45)	(−16.52)	(−16.90)
Age = 61	−1.8945	−1.6760	−1.5080	−1.8075	−1.8030	−1.8392
	(−10.67)	(−8.99)	(−8.33)	(−9.76)	(−9.84)	(−10.11)
Age = 62	−1.4035	−1.2739	−1.1792	−1.3567	−1.3548	−1.3793
	(−7.79)	(−6.93)	(−6.51)	(−7.38)	(−7.42)	(−7.57)
Age = 63	−1.0178	−1.1048	−1.1363	−1.1024	−1.1059	−1.1015
	(−5.48)	(−5.98)	(−6.15)	(−5.96)	(−5.98)	(−5.96)
Age = 64	−0.2414	−0.3323	−0.3682	−0.3248	−0.3287	−0.3238
	(−1.20)	(−1.66)	(−1.84)	(−1.62)	(−1.64)	(−1.62)
Age = 66	1.4228	1.3819	1.3616	1.3876	1.3860	1.3875
	(4.36)	(4.24)	(4.18)	(4.26)	(4.25)	(4.26)
Age = 67	0.9167	0.7985	0.7402	0.8107	0.8063	0.8116
	(3.15)	(2.75)	(2.55)	(2.79)	(2.77)	(2.79)
Age ≥ 68	1.0680	1.0241	1.0025	1.0325	1.0308	1.0326
	(4.27)	(4.10)	(4.01)	(4.13)	(4.12)	(4.13)
Constant	3.1187	2.9654	2.7042	2.9713	2.9662	2.9718
	(14.27)	(13.67)	(12.41)	(13.67)	(13.65)	(13.67)
Log-likelihood	−2,338.1	−2,336.1	−2,271.1	−2,343.6	−2,342.1	−2,343.5
N	8,577	8,577	8,577	8,577	8,577	8,577

Source: See table 9.1.

Notes: Dependent variable is dummy variable "retired." Log-likelihood value at zero is 5,954.1. Numbers in parentheses are *t*-statistics.

coefficient from all other noneconomic effects. The omission of age dummies roughly triples the estimated coefficient of the option value. Quite noticeable is the lack of spikes in the pattern of age dummies. In this sense, retirement behavior is correctly described by the option value, the main economic incentive for retirement.

Most other sociodemographic variables are not significant. The important differences between social security regulations for women and men (women can retire at age sixty if they have at least fifteen years of retirement insurance history, whereas men need thirty-five years to retire at age sixty-three, unless they claim disability) appears to be fully captured by the option value. Marital status and education is also insignificant. I did not do full justice to the retirement subsystem for civil servants. They are actually treated as if they were part of the standard social security system, which is not really the case. Civil servants are required to work longer than other employees, with a fairly rigid retirement age at sixty-five, although claims to disability are frequent, as is early retirement due to the downsizing of the civil service sector. I find an expected negative coefficient, indicating later retirement for civil servants.

One may be suspicious that a simple logit model biases results because it ignores the panel nature of the working sample. I therefore employ a panel Probit model that permits a combination of random effects and serial correlation. This model follows Börsch-Supan (2000), where all necessary econometric details are presented. It is estimated by numerical simulation methods (see Börsch-Supan and Hajivassiliou 1993). The model can be interpreted as a semi-nonparametric hazard model for multiple-spell data, permitting unobserved heterogeneity and state dependence. It is nonparametric in the sense that the model does not impose a functional form on the duration in a given state. Fairly flexible hazard rate models of retirement have been estimated by Sueyoshi (1989) and Meghir and Whitehouse (1997), although not in combination with an option value describing the incentives to retire. Parametric hazard rate models for German data have been estimated by Schmidt (1995) and Börsch-Supan and Schmidt (1996).

I estimate three models, using the probabilistic version of the option value based on the full regression (specification 4c in tables 9.1 and 9.2). Model 1 has independently and identically distributed (i.i.d.) errors and corresponds to the logit model of the last three columns of table 2. Note that Probit coefficient estimates are smaller by the square root of $\pi/6$ (which is 0.7797) than their logit counterparts. Model 2 corrects for unobserved heterogeneity by a random effect whose standard deviation is reported at the bottom of table 9. 3. Finally, Model 3 adds an autoregressive error component to Model 2. Estimation results are presented in table 9.3.

Although even the simple i.i.d. model fits the data well (the pseudo-R^2—one minus the ratio of the likelihood at the estimated parameters over the

Table 9.3 **Multiperiod Probit Model of the Retirement Decision**

	Model 1 (i.i.d.)		Model 2 (RAN)		Model 3 (RAN + AR1)	
Variable	Parameter	*t*-statistic	Parameter	*t*-statistic	Parameter	*t*-statistic
Option value	−0.0028	−3.38	−0.0110	−6.04	−0.0115	−6.81
Health	−0.1349	−9.97	−0.1029	−3.68	−0.0865	−3.26
Female	0.0745	1.11	−0.0678	−0.31	−0.1195	−0.59
Married	−0.0177	−0.23	−0.0153	−0.07	−0.0449	−0.36
Education	−0.4115	−3.96	−0.6257	−2.00	−0.6020	−1.88
Civil servant	0.3536	3.16	1.0587	3.04	1.0337	2.95
Firm pension	−2.0030	−10.93	−2.3893	−8.14	−2.2043	−7.95
Life insurance	−0.0969	−1.62	−0.2577	−2.00	−0.2123	−1.72
Stocks/bonds	−0.0028	−0.04	−0.1340	−0.86	−0.1286	−0.89
Real estate	−0.6298	−7.42	−0.9597	−5.04	−0.8639	−4.76
Owner occupation	0.2175	3.42	−0.1036	−0.55	−0.1138	−0.64
Age ≤ 59	−3.8816	−24.81	−7.6382	−21.01	−7.2894	−24.02
Age = 60	−2.8372	−18.24	−5.6820	−18.00	−5.4844	−20.32
Age = 61	−1.5157	−10.58	−3.1143	−12.13	−2.9953	−12.70
Age = 62	−1.1331	−7.85	−2.2996	−9.46	−2.2247	−9.79
Age = 63	−0.8955	−6.10	−2.0115	−8.44	−1.9826	−9.05

(*continued*)

Table 9.3 (continued)

Variable	Model 1 (i.i.d.)		Model 2 (RAN)		Model 3 (RAN + AR1)	
	Parameter	*t*-statistic	Parameter	*t*-statistic	Parameter	*t*-statistic
Age = 64	−0.2588	−1.66	−0.4417	−1.84	−0.4516	−2.06
Age = 66	0.9843	4.46	1.9338	5.68	1.8089	5.82
Age = 67	0.5858	2.83	1.3707	4.16	1.3116	4.29
Age ≥ 68	0.7606	4.24	1.8981	6.35	1.8450	6.36
Constant	2.3834	14.46	3.9641	10.87	3.7499	13.94
RAN			2.8358	19.85	2.8356	13.58
AR1					0.6093	10.66
Log-likelihood	−2,350.03		−1,808.39		−1,778.35	
Individuals	8,577		1,610		1,610	
Maximum periods	1		13		13	
N	8,577		8,577		8,577	

Source: See table 9.1.

Notes: Dependent variable is the dummy variable "retired." Log-likelihood value at zero parameter values is 5,954.1. All estimates based on twenty replications in simulated maximum likelihood estimator.

likelihood at zero—is 60.5 percent), introducing random effects increases the log-likelihood significantly: The pseudo-R^2 increases to 69.7 percent. The additional inclusion of an autoregressive component is also statistically significant: The pseudo-R^2 now rises to 70.1 percent). The prediction success is about 89 percent for all three models, the same as for the logit models.

My most important results relate to the coefficients of the option value. Taking account of the intertemporal correlations in the panel appears to be very important. The numerical value of the option value coefficient is severely underestimated in the i.i.d. model. With random effects (capturing individual specific unobserved variables) and an autoregressive error (capturing the declining influence of such shocks as illness), the coefficient estimate of the option value quadruples and is estimated much more precisely. This also holds for the endogenous specification, although to a lesser extent (see Börsch-Supan, 2000).

There is little change in the other explanatory variables across disturbance specifications, with one important exception: the estimated coefficients of the health variable, which is coded 0 for "very poor" to 10 for "excellent." As expected, the coefficients are negative. Less-healthy workers retire earlier. In the i.i.d. model, health is more significant than the option value. However, as soon as unobserved population heterogeneity is accounted for, this changes, and the estimated coefficient becomes somewhat smaller. This shows the importance to account for intertemporal linkages. In the absence of random effects, health appears to capture unmeasured population heterogeneity that is taken out by the random effects to the extent that it is time invariant.

9.5 Conclusions

The main point of the paper was to account for uncertainty and potential endogeneity of the expected retirement income in models measuring the incentive effects of public pension rules on early retirement. We were able to bracket the coefficient estimates in an option value model by the two extremes (all are eligible for disability benefits; nobody is eligible for disability benefits). However, using the endogenous specification (all those are ex ante eligible for disability benefits who have ex post disability status) yields a badly upwardly-biased coefficient (i.e., it badly exaggerates the incentive effects of pension provisions). I employ an IV approach to correct for this endogeneity, using employment and human capital characteristics as instruments in a first-stage regression that generates a fitted probability for the pathway "disabled."

I then proceeded to a more complicated stochastic model that accounts for random effects (capturing individual-specific unobserved variables) and an autoregressive error (capturing the declining influence of such shocks as illness). Such a model can be interpreted as some convenient functional form to account for individual-specific deviations from the fitted expected retirement income as well, although the model is not structural because expected retirement income enters the option value in a complicated nonlinear fashion, due to the maximization over present discounted values. Our fullest specification yields a coefficient estimate of the option value that is quadrupled relative to the i.i.d. case. Moreover, it is estimated much more precisely than by the i.i.d. model.

I thus have corrected for two effects vis-à-vis conventional models. First, I corrected for the exaggerated option value coefficient due to uncertainty and endogeneity of expected retirement income. Second, I corrected for the underestimated option value coefficient in a model that disregards the panel nature of the data. By chance, the two effects roughly compensate each other in my working sample of German workers aged fifty-five to seventy.

What do the estimated magnitudes of the option value coefficients mean in practice? Using the full model in table 9.3, one can simulate a shift from the currently less than actuarially fair system of adjustment factors (see fig. 9.2) to an actuarially fair system. This change would shift the cumulative retirement distribution function down from what it is currently, as depicted in figure 9. 5. The effect is most dramatic for very early retirement, where the discrepancy between disability and normal retirement incentives are the largest (see fig. 9.4). The policy change would cause retirement at ages fifty-nine and below to drop from 28.6 percent to about 16.5 percent.

References

Benitez-Silva, H., M. Buchinsky, H. Chan, J. Rust, and S. Sheidvasser. 1998. An empirical analysis of the Social Security disability application, appeal, and awards process. Yale University, Department of Economics, mimeograph.

Börsch-Supan, A. 1992. Population aging, social security design, and early retirement. *Journal of Institutional and Theoretical Economics* 148:533–57.

———. 2000. Incentive effects of social security on labor force participation: Evidence in Germany and across Europe. *Journal of Public Economics* 78:25–49.

Börsch-Supan, A., and V. Hajivassiliou. 1993. Smooth unbiased multivariate probability simulators for limited dependent variable models. *Journal of Econometrics* 58:347–68.

Börsch-Supan, A., and P. Schmidt. 1996. Early retirement in East and West Germany. In *Employment policy in transition: The lessons of German integration for the labor market,* ed. R. T. Riphahn, D. Snower, and K. F. Zimmermann, 83–102. Berlin: Springer.

Börsch-Supan, A., and R. Schnabel. 1998. Social security and declining labor force participation in Germany. *American Economic Review* 88 (2): 173–78.

———. 1999. Social security and retirement in Germany. In *International social security comparisons,* ed. J. Gruber and D. A. Wise, 135–80. Chicago: University of Chicago Press.

Bound, J. 1989. The health and earnings of rejected disability insurance applicants. *American Economic Review* 79:482–503.
Burkhauser, R. 1991. An introduction to the German Socio-Economic Panel for English speaking researchers. Syracuse University, Maxwell School of Public Policy, working paper.
Jacobs, K., M. Kohli, and K. Rein. 1991. Germany: The diversity of pathways. In *Time for retirement: Comparative studies of early exit from the labor force,* ed. M. Kohli, M. Rein, A.-M. Guillemard, and H. van Gunsteren, 36–66. Cambridge: Cambridge University Press.
Lumsdaine, R. L., J. H. Stock, and D. A. Wise. 1992. Three models of retirement: Computational complexity versus predictive validity. In *Topics in the economics of aging,* ed. D. A. Wise, 16–60. Chicago: University of Chicago Press.
Meghir, C., and E. Whitehouse. 1997. Labour market transitions and retirement of men in the UK. *Journal of Econometrics* 79:327–54.
Parsons, D. 1991. The health and earnings of rejected disability insurance applicants: Comment. *American Economic Review* 81:1419–26.
Rust, J. 1990. Behavior of male workers at the end of the life cycle: An empirical analysis of states and controls. In *Issues in the economics of aging,* ed. D. A. Wise, 317–82. Chicago: University of Chicago Press.
Rust, J., and C. Phelan. 1997. How Social Security and Medicare affect retirement behavior in a world of incomplete markets. *Econometrica* 65 (4): 781–831.
Schmidt, P. 1995. *Die Wahl des Rentenalters: Theoretische und empirische Analyse des Rentenzugangsverhaltens in West- und Ostdeutschland* (The choice of retirement age: A theoretical and empirical analysis of the entry into retirement in West and East Germany).
Stock, J. H., and D. A. Wise. 1990. The pension inducement to retire: An option value analysis. In *Issues in the economics of aging,* ed. D. A. Wise, 205–30. Chicago: University of Chicago Press.
Sueyoshi, G. T. 1989. Social Security and the determinants of full and partial retirement: A competing risk analysis. NBER Working Paper no. 3113. Cambridge, Mass.: National Bureau of Economic Research.
Verband deutscher Rentenversicherungsträger (VdR). 1997. *Die Rentenversicherung in Zeitreihen* (The public pension system in time series). Frankfurt am Main: VdR.

Comment Daniel McFadden

Working within the NBER framework for analysis of retirement behavior established by David Wise and various coauthors (see Hausman and Wise 1985, Stock and Wise 1990, and Lumsdaine, Stock, and Wise 1994), Börsch-Supan's paper addresses the problems presented when there are

Daniel McFadden is the E. Morris Cox Professor of Economics and director of the econometrics laboratory at the University of California, Berkeley, a 2000 Nobel Laureate in Economics, and a research associate of the National Bureau of Economic Research.

multiple paths to retirement. The setting is the German social security system, where early retirement options based on disability are an important alternative to normal retirement. This is an outstanding paper that identifies an important errors-in-variables issue in estimating option value models for retirement behavior when ex ante option values are latent. Börsch-Supan demonstrates a practical, statistically satisfactory method for dealing with this problem, and uses it to show that appropriate handling can make a big difference in the inferences one draws about the effectiveness of economic incentives in modifying retirement behavior.

The retirement decision is modeled as a series of binomial choices that depend in each year on the option value of remaining in the labor force. I have found it useful to start from a slight reformulation of the current paper's NBER model of the consumer's life-cycle planning problem. Suppose consumers are risk neutral with perfect intertemporal substitution of consumption, and discount the future at the market rate, so that their objective function from a planning age s is

$$\sum_{t=s}^{\infty} C_t \cdot \pi(t \mid s) \cdot \delta^{t-s} - \sum_{t=s}^{R-1} L_t \cdot \pi(t \mid s) \cdot \delta^{t-s}, \tag{1}$$

where C_t is consumption at age t, L_t is the consumption opportunity cost of foregone leisure when working at age t, R is the retirement age, $\pi(t|s)$ is the probability of survival at age t conditioned on survival at age s, and δ is the market discount rate.[1] The expected value of this objective function will be maximized subject to the life-cycle budget constraint

$$\begin{aligned} \sum_{t=s}^{\infty} C_t \cdot \pi(t \mid s) \cdot \delta^{t-s} &= W_s + \sum_{t=s}^{R-1} \mathrm{YLAB}_t \cdot (1 - c_t) \cdot \pi(t \mid s) \cdot \delta^{t-s} \\ &\quad + \sum_{t=R}^{\infty} \mathrm{YRET}_t(R) \cdot \pi(t \mid s) \cdot \delta^{t-s} \\ &= \mathrm{PW}_s(R) + \mathrm{SSW}_s(R), \end{aligned} \tag{2}$$

where YLAB_t is labor income at age t if working, net of taxes other than social security tax, $\mathrm{YRET}_t(R)$ is labor income at age t if retired at age R,

1. In the Stock-Wise formulation, the utility of consumption is weighted differently in work and retirement years. When hours are set institutionally for workers, rather than being chosen by optimization, this setup follows naturally from a Cobb-Douglas utility function of consumption and leisure. My reformulation follows from a utility function that is additive in consumption and a function of leisure. In the Stock-Wise formulation, intertemporal substitution of consumption through borrowing and lending is ignored, and current disposable income is fully consumed. This is a substantial simplification that, as an empirical matter, is not a bad approximation. On the other hand, private saving decisions are potentially quite important at the retirement timing margin. In my reformulation, private saving is permitted, but because of perfect intertemporal substitution of consumption, is essentially irrelevant to the retirement decision.

W_s is the value of assets (including the actuarial value of private pensions) at age s, c_t is the social security tax rate,

$$\mathrm{PW}_s(R) = W_s + \sum_{t=s}^{R-1} \mathrm{YLAB}_t \cdot \pi(t \mid s) \cdot \delta^{t-s}$$

is private wealth (the sum of current assets and the expected present value of future labor income), and

$$\mathrm{SSW}_s(R) = -\sum_{t=s}^{R-1} c_t \cdot \mathrm{YLAB}_t \cdot \pi(t \mid s) \cdot \delta^{t-s} + \sum_{t=R}^{\infty} \mathrm{YRET}_t(R) \cdot \pi(t \mid s) \cdot \delta^{t-s}$$

is the expected net present value of social security benefits. Define

(3) $$\mathrm{PL}_s(R) = \sum_{t=s}^{R-1} L_t \cdot \pi(t \mid s) \cdot \delta^{t-s},$$

the expected present value of the consumption opportunity cost of foregone leisure. Substituting the constraint into the objective function yields the result that R will be chosen to maximize the expected value of

(4) $$\mathrm{PW}_s(R) + \mathrm{SSW}_s(R) - \mathrm{PL}_s(R).$$

The option value of postponing retirement at planning age s is

(5) $$\begin{aligned} G_s &= \max_R \{\mathrm{PW}_s(R) + \mathrm{SSW}_s(R) - \mathrm{PL}_s(R)\} \\ &\quad - \{\mathrm{PW}_s(s) + \mathrm{SSW}_s(s) - \mathrm{PL}_s(s)\} \\ &= \max_R \{\mathrm{PW}_s(R) - W_s + \mathrm{SSW}_s(R) - \mathrm{SSW}_s(s) - \mathrm{PL}_s(R)\} \\ &= \max_R \left\{ \sum_{t=s}^{R-1} [\mathrm{YLAB}_t - L_t] \cdot \pi(t \mid s) \cdot \delta^{t-s} + \mathrm{SSW}_s(R) - \mathrm{SSW}_s(s) \right\}. \end{aligned}$$

Retirement occurs at the age R^* where G_s first turns negative. Let $H_s = \{\mathrm{SSW}_s(R^*) - \mathrm{SSW}_s(s)\}$; then H_s can be interpreted as the contribution of social security wealth to option value. Ordinarily one would expect $[\mathrm{YLAB}_t - L_t]$ to be a monotonically declining function of age t over the relevant age range, as worker productivity reflected in YLAB_t stabilizes or falls and the burden of working reflected in L_t rises. If this expression goes from positive to negative at an age R_N, then this is a "natural" retirement age in the absence of a social security system. If $H_s < 0$ for $s \leq R_N$, the social security system creates an incentive to retire earlier than the natural age. A necessary condition for the consumer planning at age s to retire immediately is the one-year-ahead comparison

$$\mathrm{PW}_s(s+1) + \mathrm{SSW}_s(s+1) - \mathrm{PL}_s(s+1) < \mathrm{PW}_s(s) + \mathrm{SSW}_s(s) - \mathrm{PL}_s(s),$$

or

$$\mathrm{YINC}_s \cdot [1 - \mathrm{TAXR}_s(s+1) < L_s,$$

where the implicit tax rate is

$$\mathrm{TAXR}_s(s+1) = \frac{[\mathrm{SSW}_s(s) - \mathrm{SSW}_s(s+1)]}{\mathrm{YINC}_s}.$$

A reduction in social security wealth when retirement is postponed, due to incomplete actuarial adjustment for delayed benefits, imposes an implicit tax rate on income that is a disincentive to continued work. This may be enough to trigger early retirement. It is the possibility of opportunities in the future, encoded in the option value, that prevents this condition's being necessary and sufficient; the option value may make postponing attractive even if a one-year delay is not. However, a sufficient condition for the consumer to postpone retirement is that this inequality be reversed.

To convert equation (5) to an econometric model, one could plausibly assume that the L_t are randomly distributed across individuals, with means that are functions of observed demographics. If, for example, the L_t contain additive independent Extreme Value I errors, then the binomial decision to retire now will be given by a mixed logit model, with mixing over any remaining random elements in the option values. This differs in some details from the models fitted in the paper, particularly the weighting of retirement versus wage income to account for the value of leisure, but it is essentially the same in its general approach. In particular, the mixing would permit consideration of unobserved effects that extend over a sequence of years, including individual random effects and serially correlated effects, and would provide one practical alternative to the multinomial probit analysis in the paper; see McFadden and Train (2000). The reformulated option value model makes it clear why the spectacular implicit tax rates in the German social security system, shown in Börsch-Supan's figures 9.3 and 9.4, provide a powerful incentive for early retirement.

Before turning to the issue of multiple retirement paths induced by the disability options in the German social security system, it is useful to make some general comments on the NBER formulation of the consumer's problem and the reformulation just given. First, the assumptions that the consumer is risk neutral, that consumption is perfectly substitutable between periods, and that the rate of substitution is the market discount rate times the one-year-ahead survival probability are all very special, and not necessarily realistic. Add the further assumptions that the uncertain future, conditioned on survival, can be expressed in terms of certainty equivalents, that current wealth and future income streams can be annuitized effectively into a consumption stream with the same present value, and that the consumer places no additional strategic value on new information that will be garnered if retirement is postponed. Then the retirement decision will be driven by the option value equation (5). The NBER formulation that flows from these assumptions is an analytically simple and empirically relevant approximation that provides a powerful tool for analyzing retirement behavior. It avoids the problems of a dynamic stochastic programming formulation of the life-cycle planning problem, which produces an analytic dog's breakfast. However, the assumptions listed above indicate that it has a cost in that it may miss critical interactions of saving behavior, consumption profiles, and retirement timing that can arise if intertemporal substitution is imperfect and risk aversion is significant. Furthermore, simple certainty-equivalence and independence assumptions may miss economically important interactions; for example, if uncertain retirement income is correlated with mortality risk because frail individuals are less productive and shorter lived, or because frail individuals are more likely to attain retirement paths based on disability or opt for retirement payout options that are front-loaded, then the relevant certainty-equivalent retirement income should be conditioned on individual frailty. These are already issues in the standard NBER retirement analysis, and even more so when disability-dependent retirement paths and attendant uncertain retirement income are introduced.

I turn finally to the substance of Börsch-Supan's paper, the innovative examination of the impact of multiple retirement paths induced by disability retirement possibilities in the German social security system. The relevant number for the consumer's decision is the ex ante option value of delaying retirement, taking into account the probabilities of various retirement path/retirement income alternatives. As the paper explains, if a consumer qualifies for a disability pension now or in the future, the option of early retirement may open, and the actuarial treatment of these pensions may operate to the consumer's benefit. This creates an incentive for the employee to game the system by feigning more incapacitating disabilities, possibly with the connivance of the employer if the productivity of the worker is below the legal or contractual wage level. As detective novels point out, murder is a matter of motive and opportunity. It appears that many German employees have the motive to qualify as excessively disabled; the question is how much opportunity the system provides, through lax or ambiguous standards for qualification. Börsch-Supan observes a natural experiment in which disability-qualified retirements dropped sharply following a 1972 reform that offered flexible retirement as an alternative. This could certainly have been the result of improper disability qualification before 1972; but a more benign alternative is that after 1972 the flexible retirement option was financially or administratively more attractive to individuals who might otherwise have legitimately qualified for a disability-based pension. If disability qualification is endogenous, influenced by worker productivity and commitments to work, the problem that this introduces for the economic analyst is that instead of having one-way causation from retirement income to the retirement decision, one has simultaneous determination of retirement and postretirement income.

The possibility of disability-based retirement introduces uncertainty into the option value calculation at several points. From the standpoint of the consumer, option values are uncertain because pension payments in future years will depend on whether the consumer would at those times qualify under a disability option. The paper does not spell it out, but there may also be uncertainty associated with application for a disability-qualified pension: What happens to the individual if an application is qualified at a different disability level than anticipated, or if the application is refused? Are there any downstream consequences to applying for a disability-based pension and not qualifying, such as more careful review of a subsequent application? An important econometric implication of uncertainty is that ex post observed retirement income is not the same as the ex ante certainty equivalent upon which option value–based retirement decisions are made. This can be cast as an errors-in-variables problem, with the nonlinearity of the retirement probability model precluding the simplest corrections for this problem.

The paper provides a practical solution to the errors-in-variables problem, carrying out careful reconstruction of an ex ante probabilistically weighted option value, with probabilities that are themselves estimated taking into account the reduced-form probability of being disabled. The paper also considers, for purposes of comparison, two extreme ex ante alternatives: the "tough" variant, in which no disability-based pensions are considered, and the "generous" variant, in which only disability-based pensions are considered. A final "endogenous" variant is close to an ex post representation of the option value, using the eventual classification of the individual as disabled to impute a retirement path.

It may be useful to comment on the relationship between these constructions and purely statistical methods of dealing with the nonlinear errors-in-variables problems. Abstracting from the model details, the binomial indicator r_s for retirement at age s, given no earlier retirement, has expectation $p(r_s|G_s^*)$, where G_s^* is the latent ex ante option value. The observed ex post option value G_s (which may be multidimensional) and G_s^* have a joint density $f(G_s, G_s^*|x_s)$ conditioned on exogenous variables x_s. The probability of r_s given x_s and G_s is then

$$P(r_s \mid G_s, x_s) = \frac{\int p(r_s \mid G_s^*) \cdot f(G_s, G_s^* \mid x_s) \cdot dG_s^*}{\int f(G_s, G_s^* \mid x_s) \cdot dG_s^*}.$$

If a functional form is specified for p and a parametric density for f, then the probability P can be formed analytically or numerically, and ordinary maximum likelihood estimation can be carried out using P. Alternately, one can assume that P is contained in a specified parametric family; under quite general conditions, there will exist f and p functions that are consistent with P. The approach of the paper follows the second alternative. This is just as legitimate as the first method, particularly given the lack of reliable a priori information on the forms of p and f. However, it becomes an interesting question whether the family of $\{f, p\}$ pairs that generate specified P functions are economically plausible.

The key findings of the paper are that the endogenous (or ex post) variant of the option value gives what appears to be a misleadingly large coefficient on the option value, and that the "generous" and "tough" variants introduce substantial bias. Three alternative methods are tested for construction of the probabilities in the probability-weighted option value; they all give similar results. The paper also finds significant individual random effects that appear in the sequence of decisions on retirement, and finds that ignoring these effects in applying the option value analysis leads to substantial underestimates of the coefficient on option value. The mechanism driving this result is that when individual random effects are strong, it is less likely that option values will by chance be large positive, and less likely that a decision to retire will be taken despite what appears to be a positive option value. The implication is that—unlike many discrete panel data applications in which quasi-maximum likelihood estimation ignoring serial correlation is consistent—this situation, in which the ex ante option value depends on the joint distribution of the disturbances, requires full consideration of the panel error structure to achieve consistency. While these comments suggest that there are opportunities for interesting research, I strongly endorse Börsch-Supan's main conclusion that it is important and practical to reconstruct an accurate probability-weighted option value when multiple retirement paths or pension qualifications introduce uncertainty.

References

Börsch-Supan, A., and R. Schnabel. 1998. Social Security and retirement in Germany. In *International Social Security Comparisons,* ed. J. Gruber and D. Wise, Chicago: University of Chicago Press.

Gruber, J., and D. Wise. Eds. 1999. *Social Security and retirement around the world.* Chicago: University of Chicago Press.

Hausman, J., and D. Wise. 1985. Social Security, health status, and retirement. In *Pensions, Labor, and Individual Choice,* ed. D. Wise, Chicago: University of Chicago Press.

Lumsdaine, R., J. Stock, and D. Wise. 1994. Pension plan provisions and retirement: Men and women, Medicare, and models. In *Studies in the Economics of Aging,* ed. D. Wise, Chicago: University of Chicago Press.

McFadden, D., and K. Train. 2000. Mixed MNL models for discrete response. *Journal of Applied Econometrics* 15:447–70.

Stock, J., and D. Wise. 1990a. Pensions, the option value of work, and retirement. *Econometrica* 58:1151–80.

———. 1990b. The pension inducement to retire: An option value analysis. In *Issues in the Economics of Aging,* ed. D. Wise, Chicago: University of Chicago Press.