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MODELING APPLICATION FOR DISABILITY INSURANCE AS A RETIREMENT DECISION: A HAZARD MODEL APPROACH USING CHOICE-BASED SAMPLING

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FOREWORD

This paper models the decision to apply for Social Security Disability Insurance Benefits as a special case of a more general dynamic retirement decision model. It uses a multi-state, continuous-time hazard to test the effect of policy variables on the speed at which workers apply for benefits following the onset of a work limitation. Policy variables are found to matter. A higher expected replacement rate increases the risk of application. This effect is significant in a small sample of the general population and in a sample which also includes a weighted choice-based sample of disability insurance applicants.

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David Greytak, Director
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ABSTRACT

This paper argues that it is useful to model the decision to apply for disability benefits as a special case of a more general dynamic retirement decision model. So doing, we then use a multi-state, continuous-time hazard to test the effect of policy variables on the speed at which workers apply for benefits following the onset of a work limitation. We find that policy variables matter. A higher expected replacement rate increases the risk of application. This effect is found to be significant in a small sample of the general population and in a sample which also includes a weighted choice-based sample of disability insurance applicants.

MODELING APPLICATION FOR DISABILITY INSURANCE AS A RETIREMENT DECISION: A HAZARD MODEL APPROACH USING CHOICE-BASED SAMPLING

The rapid expansion of the Social Security Disability Insurance beneficiary population in the 1970s caused concern that government policy was unduly encouraging workers to leave the labor force. An even greater rise in the percentage of older men accepting early social security retirement benefits during that period caused the same concern. These major reductions in labor supply and the increases in government expenditures that resulted from them generated numerous studies which attempted to measure the importance of social policy on these trends.

It is probably more an artifact of academic compartmentalization than a substantive difference that has caused the literature of the last decade aimed at explaining the decision to apply for disability benefits--see Leonard (1986) and Wolfe (1987) for reviews of this literature--to develop so distinctly from the even more burgeoning literature on the decision to accept an employer pension or social security retirement benefit--see Quinn, Burkhauser, and Myers (1990) for a recent review of this literature. Nonetheless, both literatures now recognize that such decisions are motivated both by economic and health considerations. And each literature has placed major emphasis on establishing the importance of social policy variables, especially social security rules, on that decision.

In this paper, we begin with a standard model from the retirement literature and show that it is a special case of a more general model which can also capture the effect of Social Security Disability Insurance (DI) on the decision of workers to "retire" early. The major distinction between the two models is that, unlike social security retirement benefits which are provided at age 62 for all those who have a sufficient earnings record, acceptance onto the disability rolls requires the worker to be judged unable to do any "substantial gainful activity." Hence, the risk of being denied benefits and the consequences of being denied must be included in this more general retirement model. Our model provides hypotheses concerning labor supply which we use to test the speed at which employed workers who develop a health condition apply for DI benefits.

In our empirical model, we explicitly argue that the application process for disability benefits is a multi-period one in which the crucial decision is how long the application should be postponed following the onset of a health condition. To capture this important dynamic aspect of the application decision, we use a multi-state, continuous-time hazard model.

Below we present a theoretical model of the decision to apply for DI. Following this, we develop an empirical hazard model. Next we discuss the data and issues of using a choice-based sample. Then we discuss hypotheses and our empirical findings. This is followed by a brief conclusion.

A Theoretical Model of Disability Insurance Application

The importance of DI on the decision by men with serious health conditions to leave the labor force has been in dispute for over a decade. Parsons (1980), for instance, argues that older workers are highly sensitive to the reward structure of the DI system relative to their market earnings. Other researchers have found that the expected replacement rate of DI transfers influences labor supply but to a much smaller degree. (See Haveman, de Jong, and Wolfe [forthcoming] for a recent paper on this subject.) Perhaps most damaging to the view that DI plays an important role in the retirement decision of health impaired men, is the finding by Bound (1989) that under 30 percent of unsuccessful DI applicants were subsequently employed and that only about two-fifths of the 30 percent worked full time.

The fact that most unsuccessful candidates never return to work does not mean, however, that DI policy does not affect the decision to work. Substantial time may elapse between the onset of a health condition, its first impact on work performance, and its subsequent influence on job exit and application for disability benefits. Moreover, application for DI is in itself a risky gamble in which the outcome can be delayed for years. Applicants for disability benefits must "invest" in not being able to work to maximize their chances in what is often a long drawn out review process.[1] What Bound has found is that for most workers, the decision to apply for benefits is tantamount to a decision to withdraw permanently from the labor market. But the size of disability benefits and the likelihood of receiving them may still be two policy levers which importantly affect the point at which health-impaired workers take that gamble.

This empirical fact uncovered by Bound suggests that one can capture the effects of the disability system on the decision to apply for disability benefits with a retirement model. For simplicity, we assume an individual's decision to apply for DI is equivalent to deciding whether or not to work. The impaired worker's problem is to choose the optimal age at which to apply for benefits. In doing so, he must compare the utility from continued work against the weighted utility of two alternative outcomes should he decide to apply for benefits: working zero hours when the application is accepted or not working again even if his application is rejected.[2]

This variation of a dynamic optimal retirement age model will be applied to the timing of the application for DI benefits. We assume a worker is initially employed at the onset of the health condition and that the condition is exogenously determined. Our underlying theoretical model is akin to the full information dynamic retirement models of Burbidge and Robb (1980) and Mitchell and Fields (1984) which assume fixed labor hours over time and find the optimal retirement age given an employer pension and social security. We use their basic assumptions including a perfect capital market, but develop a more general model by introducing uncertainty with respect to program acceptance.

Our key behavioral variable is time until application for DI. A person tries to find the optimal time to transition from work to non-work under the assumption that he will not return to work even if his DI application is rejected. Under the current DI system, one can only apply for benefits before the age of 65 since DI benefits will "expire" or automatically convert to retirement benefits after age 65.[3]

Consider an individual with a work horizon of *T* years. After the onset of a health condition (*t=0*), this horizon is segmented at the year of DI application (R). Lifetime utility is represented by:

$$V = \int_0^R e^{-\delta t}\, U(C_t, L_t)dt + \int_R^T e^{-\delta t}\, EU(C_t, L_t)dt, \qquad \textbf{(1)}$$

where δ is the discount rate, $U(C_t, L_t)$ measures utility at time t prior to application, and $EU(C_t, L_t)$ measures expected utility at each time t following application. Since the health limitation occurs at $t=0$, R measures duration until application, and T-R is the maximum period a person can be on the beneficiary rolls.

We assume fixed leisure hours L_0 denotes leisure when working and L_1 denotes leisure when not working. Equation (1) can be rewritten as:

$$V = \int_0^R e^{-\delta t} U(C_t, L_0)dt + \int_R^T e^{-\delta t}[(p)U(C_t, L_1) + (1- \qquad \textbf{(2)}$$

Equation (2) is the usual form of the time utility function except for the expected utility in the second term. Expected utility in the second term of Equation 2 is a weighted average of two possible outcomes, DI accepted or rejected, with the probability of having one's application accepted being the weight. The probability of acceptance (p) is assumed to depend on the person's health status as well as other socioeconomic variables and is assumed to be constant over time. The individual's instantaneous time separable utility function is also assumed to be separable in consumption and leisure, and the utility function has the form:

$$U(C_t, L_t) = [u(C_t) + \phi v(L_t)], \qquad \textbf{(3)}$$

where ϕ is the degree of good health with a value between 0 and 1. Higher values of ϕ imply better health.

The worker's problem is to choose C_t and the optimal time of application, R, in order to maximize the discounted expected lifetime utility subject to his lifetime budget constraint:

$$\underset{C_t,\, R}{Max}\ V$$

$$s.t.\ \int_0^R e^{-rt} W_t dt + p \int_R^T e^{-rt} B_t(R, \alpha)dt \qquad \textbf{(4)}$$

$$+ A_0 = \int_0^T e^{-rt} C_t dt$$

A_0 is initial wealth; W_t is wage income before application; and $B_t(R, \alpha)$ is potential disability benefits income with α as a parameter of the benefits formula.

Since our main concern is R, we assume that $\delta = r$ to simplify the model further. This assumption implies that the individual chooses a constant level of consumption for his pre-application years, C_0, and another constant level of consumption, C_1, for his post-application years. Because we have assumed an additive separable utility function over consumption and leisure, $C_0 = C_{14}$.

The first-order conditions for an interior solution are the budget constraint and

$$C:\ u_c = \mu e^{(\delta - r)t} = \mu \qquad \textbf{(5)}$$

$$R:\ \mu \left[e^{-rR} W_R + pe^{-rR} \left\{\frac{dB_t}{dR}\left(\frac{1-e^{-r(T-R)}}{r}\right) - B_t(R)\right\}\right] = p\phi(v(L_1) - v(L_0))e^{-rR}, \qquad \textbf{(6)}$$

where $\mu > 0$ is constant. Condition (5) shows that the marginal utility of consumption is the same as the marginal utility of wealth. Condition (6) shows that the marginal benefit of working one more year equals the loss from not applying for disability benefits in the optimum age. The left side is the gain from such a postponement expressed in terms of the marginal utility of consumption weighted by the present value of the expected income stream, whereas, the right side of this equation is the direct loss in discounted utility from further postponing application.

In the certainty case, the probability of acceptance, p, is equal to one, and we have the Burbidge and Robb (1980) or Fields and Mitchell (1984) model as a special case of this generalized model. Their comparative static results follow.

Under the simplifying assumption that a disabled worker applies for DI only once in his lifetime, application duration (R), or the time until applying for DI, approximates lifetime labor supply following the onset of a health condition. Thus, the usual testable hypotheses concerning labor supply derived from a worker choice framework are implied for our duration variable. For instance, application duration will be shorter, or the probability of application will increase: with more initial wealth, higher expected disability benefits or a higher probability of acceptance into the program, and with a decline in health.

Empirical Hazard Model

The empirical model adopted here is a variant of the hazard model used by Diamond and Hausman (1984) and Hausman and Wise (1984). Our hazard rate is the probability of applying for DI conditional on an initial state of working, and the application decision is modelled as a single transition process.

The probability that a person has applied for DI by age *t* is given by:

$$G(t) = 1 - \exp[- \int_0^t h(u)du]. \quad \textbf{(7)}$$

Associated with this distribution function is the density function:

$$g(t) = \{1 - G(t)\}\ h(t). \quad \textbf{(8)}$$

The instantaneous hazard rate is the conditional probability of applying for DI at *t*, given that the person has not applied before *t*. It is:

$$h(t) = g(t) / \{1 - G(t)\}. \quad \textbf{(9)}$$

To make the distribution function *G(t)* a function of individual attributes, we specify the hazard rate in the form:

$$h(t) = h_1(X) * h_2(t) * v. \quad \textbf{(10)}$$

The first term accounts for observable variation across individuals and is modelled as an exponential function:

$$h_1 = \exp (X'b). \quad \textbf{(11)}$$

The second component, $h_2(t)$, shows the time profile to application after the onset of a health impairment once individual differences are held constant. In order to allow flexibility, we used the quadratic form to capture time dependence:

$$h_2(t) = \exp(\alpha t + \beta t^2). \quad \textbf{(12)}$$

The third component captures unobserved individual heterogeneity. This heterogeneity may exist because of omitted variables, uncertainty or differences in the distribution function across individuals. If these differences are not controlled, then there may be spurious negative duration dependence. We report our findings using a log normal distribution to control for unobserved heterogeneity.

Since we know the beginning date of the spell, our measure of duration does not suffer from left censoring. However, some spells are right censored. In this case we only know that the true duration of the spell exceeds the observed final value, and hence, the duration is the length of time until the end of the survey. For individuals who have still not applied for benefits at that time, the probability of not applying for DI before period t_i is:

$$1 - G_i(t_i + u). \quad \textbf{(13)}$$

For individuals who applied for the DI program, the year of application is known. The probability of this event occurring between period t_j and $t_j + s_j$ is:

$$G_j(t_j + s_j) - G_j(t_j). \quad \textbf{(14)}$$

Combining complete and incomplete spell components yields the following likelihood function for the N_1 impaired persons who have not applied and the N_2 impaired persons who have applied for DI:

$$L = \prod_{i=1}^{N_1} \{1 - G_i(t_i + u)\} \prod_{j=1}^{N_2} \{G_j(t_j + s_j) - G_j(t_j)\}. \quad \textbf{(15)}$$

Data

The most recent nationally representative economic-based data set containing information on disabled workers is the 1978 Survey of Disability and Work.[4] This survey of the prevalence of work disabilities in the working age population was conducted by the Social Security Administration. It contains two sampling frames. The first is a subsample of the Health Interview Survey (HIS) and is representative of the general population of noninstitutionalized persons age 18-64. It contains data on 5652 persons. The second frame consists of 4207 persons who applied for Social Security Disability benefits (SSA).

Each respondent was asked to identify any health conditions they had and when the main health condition began. In this study, the time of onset is defined as the year when either the main health condition began to bother the respondent or when the respondent first became aware of its presence. Additional retrospective information on labor market activity including occupation, industry, job change status, and household characteristics at the time each respondent's health began to limit his ability to work is available. Information regarding application for DI is also reported.

These survey data were matched with the social security earnings records for each respondent. These data contain the yearly earnings of the worker since 1951 and the number of quarters of coverage of social security covered employment since 1938.

Combining information from the 1978 Survey of Disability and Work with social security earnings records allows us to trace an individual's economic behavior from the time his health condition first starts until the date of application for DI.

In our empirical model, we analyzed the behavior of the male working age population, i.e., those under age 60 at the survey date and older than age 20 at the onset of their main health condition. Our sample is further confined to those employed at the onset of their work limitation. Those with missing information on either time of onset or date of application are excluded.[5]

As a result of this selection process, our sample consists of 1430 observations--348 observations from the HIS sample and 1082 observations from the SSA sample.

Choice-Based Sampling

Due to the nature of a two-frame sampling approach, special attention must be paid in selecting the study sample. The major questions of interest pursued by this study are as follows:

1. Given the onset of a health condition, what determines the waiting time until a disabled individual applies for DI?
2. What factors associated with the potential population are important to the speed at which application is made?

Since the SSA frame is composed of only DI applicants, application duration can be calculated directly without censoring. However, using the SSA sample to answer this question would give us biased results because the dependent variable is time until application for disability benefits and, by definition, the SSA frame oversampled early applicants since it included only applicants. The sample proportions inconsistently estimate the corresponding population proportions. Manski and Lerman (1977) showed that treating choice-based samples as if they were random and calculating estimators appropriate to random samples yields inconsistent estimates. They introduced a weighted likelihood function which can generate consistent estimates.[6]

To obtain consistent estimators, one can use the total sample with an estimator corrected for choice-based sampling. By merging the two frames, a larger sample with a more heterogeneous distribution of health condition severity is obtained. Each observation's contribution to the log-likelihood is weighted by $P(j)/S(j)$, where $P(j)$ is the probability (density) of a person with the characteristics of person j and $S(j)$ is the sample probability (density) of a person with the characteristics of person j. This is defined based on the sample design (over sampling or undersampling certain people) and the population of applicants. These weights are available from the 1978 Survey. However, 75 persons, 22 percent of the HIS sample, appeared in the SSA sample. They are not identified in the SSA Sample. For these persons, adjusted weights are calculated. Let the weight for each sample be

$$W_s = \mathrm{pr}(x \mid \text{population}) / \mathrm{pr}(x \mid \text{SSA sample})$$

W_h = pr(x | population) / pr(x | HIS sample).

Then weight W_b for those who are listed in both samples is calculated as follows:

$$\frac{1}{1/W_s + 1/W_h} - W_s. \qquad \textbf{(16)}$$

The first part is the correct total weight for these persons, and since they appeared twice in the sample, the already assigned weight, W_s, should be deducted from the correct weight. W_s for these persons is not identified in the survey. The mean value of the weight for the SSA sample is assigned in the calculation.

Variables Affecting Job Duration

The explanatory variables in $h_1(x)$ in equation (10) are defined in Table 1. They include economic and health status variables used in equation (4), as well as control variables.

Replacement Rate

The Social Security Disability Insurance replacement rate is the key variable in most economic-based studies of the decision to apply for DI benefits. The greater the share of wage income that can be replaced by DI benefits, the more likely a worker is to apply. Currently, to receive DI benefits a worker must have sufficient quarters of coverage to be eligible for the program. And he must be unable to perform any substantial gainful activity. Roughly, the test is that a worker must have a physical or mental impairment that has prohibited him from working for five months and will make it unlikely that he can work for at least one year.

TABLE 1

DEFINITIONS OF VARIABLES

Variables	Definitions
Replacement Rate	(expected PIA)/AMW
Savings	equals 1 if a worker had savings at onset of a work limitation, otherwise 0.
Experience	quarters of coverage in all covered employment prior to work limitation.
Accommodation	equals 1 if at onset of work limitation the employer provided help to respondent to remain on the job, otherwise 0.
Age at Onset	Age at onset, years.
Married at Onset	equals 1 if married, otherwise 0.
Nonwhite	equals 1 if nonwhite, otherwise 0.
Education	Years of formal education.
White-Collar	equals 1 if the occupation at onset is professional or managerial, otherwise 0.
Physical Demand	Estimated summary scores of selected occupation characteristics.
Strength	From DOT, matched for the 591 occupational categories in the 1970 Census.
Functional Limitation	equals 1 if respondent had a functional problem in performing a task on his job, otherwise 0.
Comorbidity	equals 1 if a respondent had multiple health conditions at onset, otherwise 0.
Cardiovascular	equals 1 if the main health condition is in the cardiovascular disease group, otherwise 0.
Musculoskeletal	equals 1 if the main health condition is in the musculoskeletal disease group, otherwise 0.

We use the same method developed by other researchers (for instance: Leonard, 1979; Halpern and Hausman, 1986; and Bound, 1989) to calculate individual replacement rates. We first use the social security formula appropriate in the year of health condition onset to calculate a worker's Average Monthly Wage (AMW) and his Primary Insurance Amount (PIA). We then explicitly recognize that there is some degree of uncertainty related to acceptance onto the DI rolls by estimating a probit model of DI acceptance from a subsample of DI applicants. For the HIS frame, we can only use DI applicants. An expected benefit is calculated for each worker by multiplying this value by the worker's PIA adjusted for dependents.

Because we can only use those workers who actually applied for benefits in obtaining our probability of acceptance measure, we may have a selection problem. By using a bivariate probit model with a selection correction, we are able to check for this possibility. This was done and we found no significant selection bias in our sample. A detailed discussion of this work is available in Appendix B which will be supplied by the authors upon request.

Our measure of a worker's replacement rate is the expected value of his DI monthly benefit divided by his AMW at the time of onset of his health condition. We follow the work of others in interpreting the AMW as a measure of the worker's permanent wage.

Wealth

We would like to hold wealth constant in our model. Unfortunately, little information is available on this variable at the point of onset of a health condition. We approximate this value by the use of a binary variable that is positive if the worker had savings at onset.

Accommodation

Most economic models of DI application ignore the importance of an employer's behavior on this outcome. Yet the willingness of an employer to adjust the workplace to compensate for an employee's work limitation may play an important role in allowing the worker to continue on his job. This is certainly the belief of those who supported recent legislation which requires employers to accommodate disabled workers. The Americans with Disabilities Act of 1990 (ADA) requires employers to provide reasonable accommodations to disabled workers as long as these accommodations do not create an undue hardship on the operation of business. Our pre-

ADA data allow us to capture the effect of accommodation on DI application. A variable reports whether an employer did anything to accommodate the worker when his health condition first began to affect his ability to do his job. We expect accommodation to reduce the risk of applying for DI.

Experience

We expect a worker with more experience in the job market to have greater human capital and, hence, to be slower to apply for benefits.

Other Socioeconomic Variables

Age at Onset, Marital Status at Onset, Race, and Education are also included in our empirical model. Marital status, higher education, younger age, and non-black race are generally found to increase work effort, and hence, we expect them to reduce the risk of application.

Job Characteristics

Several researchers have looked at the importance of job attributes on the decision of workers to retire. We report our finding using a binary variable to distinguish white-collar workers, but we also used more elaborate job attribute measures developed by Roos and Treiman (1980) from the Dictionary of Occupational Titles. These measures were used by the Social Security Administration in their, report Social Security Administration (1986). We expect that an impaired worker in a more physically demanding job has a higher risk of applying for DI benefits.

Health Measures

Finally, we attempt to account for variations in health within our sample by use of a function limitation variable as well as by accounting for comorbidity to see if different types of health conditions influence duration. We choose the two most common physical conditions among the DI population, cardiovascular and musculoskeletal conditions, and a measure of multiple conditions. We expect that those suffering from functional limitations or from multiple conditions are more likely to apply for DI benefits than less impaired workers.

Results

A univariate interval hazard technique was used to estimate the model. The results are presented in Table 2. In the first equation we use the HIS sample. The second equation combines the HIS sample with the SSA sample, controlling for choice-based sampling. The results are very similar, and not surprisingly, the t-values are higher in the larger sample. In both equations, we allow for unmeasured heterogeneity and assume that it follows a log normal distribution.

Consistent with previous research on the decision to apply for DI benefits, we find that a higher expected replacement rate increases the risk of application after the onset of a work limiting condition. This finding differs from previous studies since it measures the speed to application, but it is similar in its support of the hypothesis that this policy variable affects the application decision even of the health impaired. Our wealth variable also significantly increases application risk as predicted by our model.

Only our study of DI application attempts to control for an employer's willingness to accommodate a worker who becomes impaired. We find that those workers who are accommodated apply for DI benefits less quickly. In contrast, we find overall experience in the work force has no significant effect on job exit.

Of the other socioeconomic effects in the equation, older workers were more likely to apply for DI benefits, as were the less educated and whites. Marital status at onset was not significant.

Occupation related variables representing physically demanding jobs also have an insignificant effect. This was true whether our measure was a simple binary variable indicating a white-collar job, as shown here, or more sophisticated scales of physical characteristics required by occupation. This is a somewhat surprising finding, and it may be that the variation within these classification schemes is greater than across classifications.

Those with functional limitations were more likely to apply for benefits. This is an important finding since it shows that the severity of the limitation is an important predictor of

TABLE 2

ESTIMATED HAZARD OF APPLICATION FOR SOCIAL SECURITY DISABILITY INSURANCE

	HIS Sample (n=348)		Combined Sample (n=1430)	
Explanatory Variables	**Coefficients**	**t-Value**	**Coefficients**	**t-Value**
Constant	-4.33*	-4.17	-1.51*	-3.27
Replacement Rate	4.01*	4.99	4.49*	9.90
Had Savings	-0.02	-0.01	0.02**	2.50
Experience	-0.02	-.04	0.03	1.80
Accommodation	-0.77*	-2.91	-0.66*	-5.94
Age at Onset	0.04**	2.06	0.02*	2.74
Married at Onset	0.29	1.14	0.03	0.29
Nonwhite	0.13	0.44	-0.44*	-2.60
Education	-0.01	-0.31	-0.07*	-6.80
White-Collar	-0.33	-0.89	0.14	1.30
Function Problem	0.50**	2.14	0.39	4.48
Comorbidity	-0.07	-0.28	-0.06	-0.07
Cardiovascular	0.30	0.87	0.17	1.57
Musculoskeletal	-0.63**	-2.43	-1.11*	-9.08
Time	-0.27*	-3.72	-0.17*	-4.33
Time Squared	0.01*	4.13*	0.01*	4.57
Sigma Squared	0.91	0.97	0.91	1.79

*Significant at 1 percent.
**Significant at 5 percent.

application even in a sample in which everyone has a job-impairing health condition. Hence, the variation in health is less than in most other studies of disability. Comorbidity was not significant, but it may be a poor proxy for severity of health.

The coefficients of time in Table 2 capture time dependence controlled for observed and unobserved heterogeneity. In both equations negative time dependence is found. The average person in the sample applies for benefits after 7.7 years. The risk of application falls for 12.8 years. Thus, the risk falls for most people for most of the relevant period.

Conclusion

Bound (1989) has shown that the decision to apply for Social Security Disability Insurance benefits is in effect a decision to retire early for most health-impaired workers, since even those who are eventually denied benefits rarely return to work. As we show, however, this does not mean that the decision to work is unaffected by DI policy variables. Using a dynamic optimal retirement age model we show that the size of DI benefits and the likelihood of receiving them should affect the speed at which health-impaired workers apply for such benefits and effectively retire from the work force. Using a univariate interval hazard technique, we show that the expected replacement rate significantly affects the timing of application, as do other economic variables, including whether the worker had savings and whether his employer provided accommodation on the job.

Our findings suggest not only that public policy has influenced the speed at which health-impaired individuals apply for DI benefits but that it can slow down as well as increase the decision to do so. If a goal of disability policy is to encourage health-impaired workers to stay in the work force, our results suggest that the timing of that intervention is important. It should occur prior to application for benefits. Bound's findings show that return to work is unlikely once a worker has gone through the DI process. Our work suggests that a lower expected replacement rate will delay applications but so will greater accommodation on the job. Both policy tools influence workers' plans while these plans are still in the formative stage and, hence, are more likely to have an impact on subsequent work.

APPENDIX A

Acceptance Model with Return to Work Assumed if Benefits Are Denied

Consider an individual with a horizon of *T* years. Assume that since the onset of a health condition (*t=0*), a physically or mentally impaired individual's lifetime can be divided into two segments, one in which the individual has not applied for DI and one in which the individual has applied. Then lifetime utility may be represented by

$$V = \int_0^R e^{-\delta t} U(C_t, L_t)dt + \int_R^T e^{-\delta t} EU(C_t, L_t)dt, \qquad \textbf{(A-1)}$$

where δ is the discount rate, $U(C_t, L_t)$ is the utility at time *t* before applying, and $EU(C_t, L_t)$ is the expected utility at time *t* from applying for DI. *R* is the time of application for DI, and *T* is the end of the lifetime. If we assume that the health limitation occurs at *t=0*, then *R4* is also interpreted as duration until application, and *T-R* is the period during which a person expects to be on the beneficiary rolls if he applies and is accepted. Following Halpern and Hausman (1985), our model assumes that when a worker's application is rejected, he will return to work.

We assume fixed labor hours. L_0 denotes leisure when working, and L_1 denotes leisure when not working. Then equation (A-1) can be rewritten as:

$$V = \int_0^R e^{-\delta t} U(C_t, L_0)dt + \int_R^T e^{-\delta t}[(1-p)U(C_t, L_0) + pU(\qquad \textbf{(A-2)}$$

Equation (A-2) is the usual form of lifetime utility function except for the expected utility in the second term. It shows that the expected utility is obtained as a weighted average of two possible utility paths, defined by the application for disability being accepted or rejected, with the probability of having one's application accepted being the weight. Basically this assumes that the only uncertainty involved is that the applicant does not know whether he will be accepted. The probability of acceptance *(p)* is assumed to depend on the person's health status as well as other socioeconomic variables and is considered to be constant over time. The individual's instantaneous time separable utility function is also assumed to be separable in consumption and leisure, and the utility function has the form:

$$U(C_t, L_t) = [u(C_t) + \phi v(L_t)], \tag{A-3}$$

where ϕ is the degree of good health or the inverse of severity of a health condition, with a value between 0 and 1. A higher number on this parameter implies a better health status, and it is assumed to be constant. By rewriting, we get equation (A-4):

$$V = \int_0^R e^{-\delta t}[u(C_t) + \phi v(L_0)]dt$$
$$+ \int_R^T e^{-\delta t}[(1-p)\{u(C_t) + \phi v(L_0)\} + p\{u(C_t) + \phi v(L \tag{A-4}$$

The worker's problem is to choose C_t and the optimal time of application, R, in order to maximize the discounted value of lifetime utility subject to his lifetime budget constraint:

$$\underset{C_t,R}{Max V}$$

$$s.t. \int_0^R e^{-rt}(1-z)W_t dt + p\int_R^T e^{-rt} B_t(R, \alpha)dt \tag{A-5}$$
$$+ (1-p)\int_R^T e^{-rt}(1-z)W_t^{/} dt + A_0 = \int_0^T e^{-rt} C_t dt$$

$$\text{and } W_t^{/} \le W_t. \tag{A-6}$$

A_0 is initial wealth, z is the proportional payroll tax rate on earnings, W_t is wage income before application, $B_t(R, \alpha)$ is potential disability benefits income with α as a parameter of the benefits formula, and $W_t^{/}$ is the new lower-wage income encountered when the worker tries to reenter the labor market after the application is denied. Assume that $\delta = r$ to simplify the model further. This assumption implies that the individual chooses a constant level of consumption for his pre-application years, C_0, and another level of consumption, C_1, for his post-application years. Due to the assumption of an additively separable utility function over consumption and leisure, $C_0 = C_1$.

The first-order conditions for an interior solution are the budget constraint and

$$C: u_c = \mu e^{(\delta - r)t} = \mu \quad \textbf{(A-7)}$$

$$R: \ \mu[e^{-rR}(1-z)\{W_R - (1-p)W_R^{/}\} + pe^{-rR}\frac{dB_t}{dR}(\frac{1-e^{-r(T-R)}}{r}) = p\phi\,(v(L_1) - v(L_0))e^{-rR} \quad \textbf{(A-8)}$$

where $\mu > 0$ is constant. These first-order conditions can be interpreted as follows. Condition (A-7) says the marginal utility of consumption is the same as the marginal utility of wealth. Condition (A-8) shows that the marginal benefit should be equal to the marginal cost of working, i.e., postponing application for one more year at the optimum. The left side is the gain from such postponement expressed in terms of the marginal utility of consumption weighted by the present value of expected income streams, whereas the right side of this equation is the direct loss in discounted utility from further postponement of applying. At the margin, these gains and losses are balanced out.

Comparative Static Results

A total differentiation of the first-order conditions of the system yields the following:

$$\begin{bmatrix} u_{cc} & 0 & -1 \\ 0 & \mu K_1 & p\phi(v_1 - v_0)/\mu \\ -(1 - e^{-rT})/r & p\phi(v_1 - v_0)/\mu & 0 \end{bmatrix} \begin{bmatrix} dC \\ dR \\ d\mu \end{bmatrix} =$$

$$\begin{bmatrix} 0 & 0 & 0 & 0 \\ p(v_1 - v_0) & 0 & K_2 & K_3 \\ 0 & \mu & K_4 & K_5 \end{bmatrix} \begin{bmatrix} d\phi \\ dA^0 \\ d\alpha \\ dp \end{bmatrix}$$

$$K_1 = \frac{1 - e^{-r(T-R)}}{r} \frac{\delta^2 B}{\delta R^2} - (1 + e^{-r(T-R)} \frac{\delta B}{\delta R} + (1-z) W_R,$$

$$K_2 = - \mu p \{ \frac{\delta^2 B}{\delta R \delta\alpha} \frac{1-e^{-r(T-R)}}{r} - \frac{\delta B}{\delta R} \}$$

$$K_2 = \phi(v_1 - v_0) + \mu\{ (1-z) W_R^{/} + \frac{\delta B}{\delta R} \frac{1 - e^{-r(T-R)}}{r} - B_R \},$$

$$K_4 = 0\, p \frac{\delta B_t(\alpha)}{\delta\alpha} \frac{e^{-rR} - e^{-rT}}{r}, \quad \wedge$$

$$K_5 = \{B - (1-z) W_R^{/} \} (\frac{e^{-rR} - e^{-rT}}{r}).$$

where $v_1 = v(L_1)$, $v_0 = v(L_0)$. Let $|J|$ be the determinant of the 3 x 3 matrix on the left side. Given diminishing marginal utility of consumption, i.e., $u_{cc} < 0$, and K_1 is negative as assumed in Burbidge and Robb (1980), $|J|$ will be positive, and the second-order conditions for the problem will be met. Since our main concern is effects on the time of application, we will focus on effects of various factors on R only.

For a change in health status, ϕ, we obtain:

$$\frac{dR}{d\phi} = \frac{1}{|J|} \{ \frac{1 - e^{-rT}}{r} p\, (v_1 - v_0) \} > 0 \qquad \textbf{(A-9)}$$

That is, a decline in health would reduce the application duration R and, hence, speed up DI application.

In case of a change in initial wealth, A_0, we obtain:

$$\frac{dR}{dA_0} = \frac{1}{|J|} \{ u_{cc} \frac{p\phi(v_1 - v_0)}{\mu} \} < 0 \qquad \textbf{(A-10)}$$

Suppose that the benefits formula includes a parameter α, which can result in a change in benefits structures. Then for a change in α, assuming that the shift in disability benefits induced by a change in α did not alter the rate at which disability benefits change with the age of retirement ($\delta B^2/\delta R\delta\alpha = 0$), we obtain:

$$\frac{dR}{d\alpha} = \frac{1}{|J|}[\{u_{cc}\frac{-p\phi(v_1 - v_0)}{\mu}K_4\} - \{\frac{1-e^{-rT}}{r}K_2\}] < 0 \qquad \textbf{(A-11)}$$

since $K_4 < 0$ and $K_2 < 0$. In these circumstances, an increase in α reduces the age of application or raises the risk of application.

Finally, in case of a change in the probability of successful claim, p, we obtain:

$$\frac{dR}{dp} = \frac{1}{|J|}[u_{cc}K_5\frac{p\phi(v_1 - v_0)}{\mu} - \frac{1-e^{-rT}}{r}K_3] \qquad \textbf{(A-12)}$$

Note that $K_3 > 0$ from the first-order condition. Then as long as $[B - (1-z)W_R'$ in K_5 is positive (or at least a small negative so that the terms in brackets in (1A-2) remain negative), (A-12) is negative. That is, if DI benefits are greater than, or at least less than by a small amount, the post-application wage income, then a higher likelihood of acceptance to the disability program would speed up application for DI.

Allowing the Decision to Return to Work to be a Choice Variable

If an applicant is rejected, then he has to decide whether to return to work by comparing the post-application wage with the shadow wage. The following is a sketch of a generalized model that introduces this possibility formally.

The worker's problem is to choose C_t and the optimal time of application, R, in order to maximize the discounted value of lifetime utility subject to his lifetime budget constraint:

$$V = \int_0^R e^{-\delta t}U(C_t, L_0)dt + \int_0^T e^{-\delta t}[(1-p)\,U(C_t, L_0) + pU(\qquad \textbf{(A-13)}$$

$$s.t. \quad \int_0^R e^{-rt}(1-z)W_t dt + p\int_R^T e^{-rt} B_t(R, \alpha)dt$$
$$+ (1-p)\int_R^T e^{-rt}(1-z)W_t^{/} dt + A_0 = \int_0^T e^{-rt} C_t dt \qquad \textbf{(A-14)}$$

$$\text{and } W_t^{/} \le W_t \qquad \textbf{(A-15)}$$

where A_0 is initial wealth, z is the proportional payroll tax rate on earnings, W_t is the wage income before application, $B_t(R, \alpha)$ is the potential disability benefits income with α as a parameter of the benefits formula, and $W_t^{/}$ is the new lower-wage income encountered when the applicant tries to return to the labor market after the application is denied.

Now let us introduce another uncertainty and let q be the probability of returning to the labor market after one's application is denied. By including this component, we have

$$V = \int_0^R e^{-\delta t}U(C_t, L_0)dt + \int_R^T e^{-\delta t}\,[(1-p)q\, U(C_t, L_0)$$
$$+ (1-p)(1-q)\, U(C_t, L_1) + pU(C_t, L_1)]dt \qquad \textbf{(A-16)}$$

$$s.t. \quad \int_0^R e^{-rt}(1-z)W_t dt + p\int_R^T e^{-rt} B_t(R, \alpha)dt$$
$$+ (1-p)q\int_R^T e^{-rt}(1-z)W_t^{/} dt + A_0 = \int_0^T e^{-rt} C_t dt \qquad \textbf{(A-17)}$$

$$\text{and } W_t^{/} \le W_t \qquad \textbf{(A-18)}$$

This is a more generalized model. Our model presented in the appendix above is a special case for a value of $q=1$. On the other hand, if we assume $q=0$, i.e., no return to work after denial of a DI claim, as we did in the paper, uncertainty in the utility function disappears and we have a certainty model except for the second term in the budget constraint.

APPENDIX B

Calculation of the Expected Replacement Rate

We follow Leonard (1979) in our calculation of expected disability benefits. We first determine if a worker is eligible for benefits based on his years of tenure, then we compute his potential benefits using information from his past earnings history. Then using a subsample of recent applicants from the 1978 Survey of Disability and Work, we impute the probability of acceptance using a univariate probit model. We then calculate an expected benefit by multiplying these two variables.

Rules for calculating Average Monthly Wage (AMW) and Primary Insurance Amount (PIA) vary over the period of our analysis. Since we are interested in the expected replacement rate in the year that a worker first experienced a work limiting health condition, we used the rules in that year to estimate AMW and PIA based on the worker's earning history to that point. In general, we calculated a worker's AMW by first summing his yearly social security earning beginning at age 21 (or in 1951 for those older than 21 in 1951) and ending in the year his health condition first began to affect his work and then dividing that sum by the number of months in the benefit computation years. After calculating the AMW, we used the formula appropriate for the onset year to estimate PIA.

In order to calculate expected disability benefits for the workers in our HIS sample, it was necessary to estimate their probability of acceptance into the DI program. This probability was estimated using a standard univariate probit equation. However, in our estimation we only use those HIS sample members who applied for DI. Hence, our calculation may be subject to selectivity bias. In the disability literature that is based on cross-sectional research, it is assumed that there is no selectivity bias in the sample, i.e., that the sample of actual applicants used to estimate the equation does not differ from the population of applicants and nonapplicants (Leonard, 1979; Hausman, 1985; Halpern and Hausman, 1985, 1986). The rationale for this assumption, as suggested by Halpern and Hausman (1986), is that the statutory and actual criteria used by the Social Security Administration involve observable characteristics that can be quantified in both applicants and nonapplicants. While we used the univariate probit equation from our HIS sample in our analysis, we also estimated a model of DI application and acceptance which permitted us to test for selectivity.

Testing For Selection

To test for possible selection, a simultaneous equations system was used. The dependent variables in our model--application for DI and acceptance into DI--are binary variables; so we tested a bivariate model with sample selection. Formally we have the following equation systems:

$$Y_1^* = Xa + e_1 \quad \textbf{(B-1)}$$

$$Y_2^* = Zb + g\,(\text{P * Replacement Rate}) + e_2 \quad \textbf{(B-2)}$$

$$Y_j = 1 \text{ if } Y_j^* > 0 \text{ and 0 otherwise, } j = 1, 2. \quad \textbf{(B-3)}$$

Here e_j follows N (0, 1) with ϕ equal to the correlation between e_1 and e_2. Y_2^* is the unobserved index for a propensity of application, P is the probability of acceptance (i.e., the probability that Y_1^* is greater than zero), and Y_1 is observed only when $Y2 = 1$. As suggested above, the expected replacement rate term is included in the equation for the DI application decision and is calculated by multiplying the replacement rate by the probability of acceptance, which can be imputed from equation (B-1)--(P * replacement rate).

This is a selectivity model in which estimation of the coefficient (a) using only DI applicants yields inconsistent estimates if the correlation between the two error terms, e_1 and e_2, is not equal to zero. The LIMDEP program package provides a full information maximum likelihood estimation method to solve the problem.

As an approximation, Heckman's two-step selectivity correction procedure (Heckman, 1979) may also be used to correct for this potential bias. One main difference between the Heckman procedure and ours is that the dependent variable in the selected sample (Y) is binary while it is continuous in Heckman's example. Van de Ven and Van Praag (1981) showed how the Heckman procedure can be applied to the bivariate probit situation.

There exists yet another difficulty in estimating the above equation system. Since the probability of acceptance into DI, *P*, included in equation (B-2) is not observed, we must use a proxy in our estimation. Two alternative proxies were tried. First, the probability of acceptance equation was run using only DI applicants and assuming the absence of selectivity. An alternative proxy measure was estimated based on the assumption that the probability of acceptance is initially one for everyone in the HIS sample. In other words, a bivariate probit model with sample selectivity was run to estimate the coefficients for the acceptance equation by assuming that the *P* term used to calculate the expected replacement rate in the application equation is equal to one. Table B-1 shows, for the HIS sample, two estimated probability of acceptance equations as an intermediate step in estimating *P*. These estimated coefficients were then used to calculate the predicted values of the probability of acceptance for the whole sample of both applicants and nonapplicants. Using these proxies, a bivariate probit model was then estimated controlling for selectivity.

The first two columns in Table B-2 show the bivariate probit estimation results based on the two alternative proxies using the HIS sample. The third column shows the result of a simple univariate probit estimation of the probability of acceptance equation using the SSA sample for which no adjustment is required since it only includes those who applied for DI. While the result of the acceptance equation of the SSA sample and that of the HIS sample are considerably different, the results from the HIS sample based on the two alternative measures of instrumental variables are only slightly different. What is important for our work, however, is that using either proxy the correlation between the error terms in the two equations is not significantly different from zero. Hence, selectivity does not play an important role in the HIS sample.

TABLE B-1

PROBIT MODEL FOR PROBABILITY OF ACCEPTANCE:
FIRST STAGE TO OBTAIN *P*

Explanatory Variables	Alternative I (n=181)		Alternative II (n=348)	
	Coefficients	**t-value**	**Coefficients**	**t-value**
Constant	-0.601	-0.786	0.051	-0.057
Age at Onset	0.015	0.870	0.006	0.309
Married at Onset	0.676*	2.658	0.619**	2.178
Nonwhite	-0.056	-0.218	-0.098	-0.384
Had Savings	-0.189	-0.896	-0.162	-0.736
Education	0.018	0.591	0.027	0.955
Experience	0.002	0.513	0.003	0.584
Comorbidity	-0.381	-1.506	-0.365	-1.332
Function Problem	0.156	0.743	0.075	0.341
Cardiovascular	0.133	0.425	0.088	0.290
Musculoskeletal	-0.590**	-2.196	-0.406	-1.276
Pulmonary	-0.468	-0.978	-0.431	-0.903
Psychiatric	0.236	0.526	0.225	0.579
Log-Likelihood	-105.7		-317.5	

*Significant at 1 percent.
**Significant at 5 percent.

Alternative I: univariate probit model based on only HIS applicant sample with assumption of no selectivity.

Alternative II: bivariate probit model with selection based on entire HIS sample with the assumption that the probability of acceptance is 1. The probability of application portion from the simultaneous system is not reported.

TABLE B-2

PROBIT MODEL OF PROBABILITY OF ACCEPTANCE

Variables	HIS (n=348) Bivariate Probit with Selection				SSA (n=1082) Univariate Probit	
	I		II		III	
	Probability of Acceptance					
	Coefficients	t-Value	Coefficients	t-Value	Coefficients	t-Value
Constant	-0.846	-0.89	- 0.693	-0.84	0.853	2.58
Age at Onset	0.019	0.90	0.017	0.85	0.001	0.04
Married at Onset	0.704**	2.49	0.693**	2.45	0.056	0.47
Nonwhite	-0.051	-0.19	-0.059	-0.22	0.091	0.03
Had Savings	-0.203	-0.89	-0.197	-0.86	0.068	0.66
Education	0.015	0.47	0.017	0.58	0.001	0.03
Experience	0.002	0.49	0.003	0.53	0.002	0.80
Comorbidity	-0.392	-1.34	-0.398	-1.30	0.029	0.26
Function Problem	0.180	0.79	0.162	0.73	-0.041	-0.42
Cardiovascular	0.139	0.43	0.131	0.41	0.172	1.20
Musculoskeletal	-0.654**	-2.06	-0.617**	-2.12	-0.252	-2.00
Pulmonary	-0.488	-0.98	-0.490	-0.97	0.196	0.94
Psychiatric	0.235	0.57	0.232	0.55	-0.057	0.28
	Probability of Application					
Constant	-1.424**	-2.22	-2.610*	-2.69		
Exp. Replacement Rate	2.341*	5.68	6.034*	10.48		
Age at Onset	0.030**	2.36	0.028	1.58		
Married at Onset	0.255	1.29	0.802*	3.02		
Nonwhite	0.151	0.73	0.109	0.47		
Had Savings	-0.045	-0.28	-0.069	-0.32		
Education	-0.023	-0.89	-0.019	-0.54		
Experience	-0.003	-0.74	-0.004	-0.91		
Help	-0.536*	-3.24	-0.507**	-2.48		
White-Collar	-0.245	-0.96	-0.329	-0.78		
Comorbidity	0.106	0.61	0.167	0.66		
Function Problem	0.257*	1.63	0.366	1.79		
Cardiovascular	0.050	0.19	-0.046	-0.13		
Musculoskeletal	-0.464*	-2.64	-0.591*	-2.62		
Rho (1, 2)	0.172	0.39	0.076	0.29		
Log-Likelihood	-304.4		-238.8		-434.5	

Calculation of Job Characteristics

When Congress passed the Social Security Amendments of 1983 increasing the social security retirement age beginning after the turn of the century, it mandated a study of the implications for workers in physically demanding jobs. To fulfill this mandate, the Social Security Administration had to determine appropriate criteria for identifying physically demanding jobs. Since the Dictionary of Occupational Titles (DOT) was the only available systematic source of data for classifying occupations according to the degree of physical demands, three criteria based on DOT were developed in their report (Social Security Administration 1986). The DOT uses 44 job characteristics to evaluate occupations and, based on job descriptions, scores for each characteristic are assigned to occupations. These characteristics measure complexity of functions, training and education, aptitudes, temperaments, interests, physical demands, and working conditions. The three measures chosen by the Social Security Administration were: the strength variable in the physical demand characteristics group, a multiple-item scale variable composed of characteristics representing physical demands based on statistical analysis, and a composite strength measure based on stoop and climb variables. In its final report to the Congress, the narrow strength variable was used. The strength measure has the virtues of clarity of meaning, appropriateness, and simplicity combined with some detail in scoring: 1-to-5 scale reflecting sedentary, light, medium, heavy, and very heavy work. However, two potential drawbacks of this variable are that the variation in jobs within classifications may overwhelm the variation across classifications and that the job classification based on a single variable is too narrow. Hence, we use this measure with our HIS sample but also include a second measure.

The second alternative examined by the Social Security Administration was a multiple-item scale based on the work of Roos and Treiman (1980). They estimated summary scores of selected DOT characteristics for the 591 occupational categories in the 1970 Census. To do this, they averaged DOT scores for all individuals in each category with weights proportional to the number of individuals holding each DOT occupation. As a first step, they present these scores for each of eight occupational characteristics in the fourth edition of DOT: DATA, PEOPLE, THINGS, GED (general educational development), SVP (specific vocational preparation), STRENGTH, PHYSDEM (physical demands), and ENVIRON (environmental condition). Since the DOT worker function and worker trait variables are highly intercorrelated, they develop four multiple-item scales of the major underlying dimensions using factor analysis: substantive complexity, motor skills, physical demands, and undesirable working conditions. One of these, the composite physical demands scale includes: EYEHAND (aptitude), CLIMB (physical demand), STOOP (physical demand), LOCATION (working condition), and HAZARDS (working condition). This composite characteristics measure has a 0-10 range (the lowest-scoring occupation is coded zero). For instance, the score of physical demands is 0.1 for economists and 8.7 for firemen. Note that the resulting scale does not include the strength, prime physical demands characteristic. Equal weights were assigned for all of the included characteristics arbitrarily. We also calculated this multi-item scale for all our HIS sample workers.

The strength/stoop/climb composite, the third alternative, is a useful complement to the strength variable. However, it is not a preferred substitute, since it adds some complexity but it does not add much new information. In fact, the Social Security Administration chose the simple strength measure as the best measure for physically demanding jobs in its final report to Congress (Social Security Administration 1986). We did not use this scale.

Since occupations in the 1978 Survey of Disability and Work are coded on the basis of the 1970 Census classification system, the imputed scores developed by Roos and Treiman (1980) can be directly converted to our sample. We call the simple straight variable Physical Demands in our analysis. We call the multiple-item scale Strength. Our binary variable which separates professional and managerial positions from other occupations we call White-Collar.

We report our finding using the White-Collar variable in the text. It was found not to affect duration significantly. In alternative equations using the other two variables, we found similar results. In addition, we found that the use of the other two measures of job characteristics had no effect on the significance of other variables.

Endnotes

1. See Weaver (1986) for a discussion of the DI determination and appeals process.

2. A more complex model would allow for the possibility that an unsuccessful applicant would return to the labor market. Halpern and Hausman (1986) develop such a model. In appendix A, available upon request, we show the comparative statics of such a model in which a worker's expected wage falls after unsuccessful application and he must decide whether or not to return to work.

3. See Haveman, Wolfe, and Warlick (1986) for a model of this decision. In fact, a disabled person aged 62 to 65 has three options; working, DI application, or early retirement. For those age groups, the decision to apply for DI can be intertwined with the usual retirement decision.

4. For technical details, see Bye and Schechter (1982).

5. Some respondents made multiple applications for the program. The questionnaire asked only the date of the last application. If we use only the first applicant sample, there may be a selectivity problem. Fortunately, our interval hazard estimation technique allows us to use all applications. The time of the first application, which is the one we analyze, must be before the last application, and thus, an interval from zero to the time of the last application includes the time of the first application.

6. See also Manski and McFadden (1981), Hausman and Wise (1981), and Heckman and Robb (1985).

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