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LATE CAREER JOB LOSS AND THE DECISION TO RETIRE*

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This article provides an empirical analysis of the effect of involuntary job loss on the lifetime income and labor supply of older workers. I develop and estimate a dynamic programming model of retirement with savings, costly job search, and exogenous layoffs. The average cost of job loss is equivalent to one year of predisplacement earnings, 70% due to the wage reduction and 30% to the search frictions. Displaced workers on average retire 14 months earlier. Workers who approached retirement during the Great Recession will work approximately five months longer in response to the contemporaneous financial and labor market shocks.

1. INTRODUCTION

Every year over the last decade, well over a million U.S. workers aged 55 and older lost their jobs to layoffs. More than one-fifth of the 2010 population between the ages of 60 and 65 have been displaced at least once since turning 50. In the meantime, the labor force participation of individuals older than 55 went up to 40%, a 10 percentage point increase relative to 1990. As the fraction of people who remain employed well into their sixties keeps on growing, those workers increasingly rely on old age earnings. The exposure and vulnerability of an aging workforce to the consequences of job loss manifested themselves most recently during the Great Recession, when unemployment rates among older persons reached a historical maximum.[2]

In this article, I examine how job loss experienced by senior workers at different stages of the business cycle affects their labor force attachment, their take-up of Social Security, and their lifetime income. I show that involuntary separation at an older age results in substantial economic loss for the affected individuals. On average, the cost of job loss for a 60-year-old male worker computed as an amount of compensation required to keep him indifferent between the states of employment and unemployment due to displacement amounts to 37,000 dollars. This is approximately equivalent to the annual wage earned at this age, a large amount taking into account that the remaining working life for the majority of affected workers is relatively short. The main source of this cost is the reduction of postdisplacement wages, which accounts for 70% of the total. The remaining 30% is due to search frictions, including the cost of job search and the loss of earnings over the spells of unemployment that follow a job loss.

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[2] Data sources: The number of workers displaced between 2001 and 2011 is computed from the Current Population Survey (CPS) Displaced Workers Supplement. The fraction of older workers affected by layoffs comes from the Health and Retirement Study (HRS) data set. The labor force participation and unemployment rates are obtained from the CPS.

The effect of involuntary separations on the timing of retirement is not straightforward. Laid-off individuals face the cost of searching for a new job that is likely to yield lower earnings. Displacement may encourage some of these workers to leave the labor force sooner than they had planned and to take up Social Security at an earlier age. Others may prefer to work longer to replenish their retirement savings that may have been depleted in the course of a postdisplacement unemployment spell. These decisions will obviously depend on the labor market conditions and vary over the business cycle. The problem is further exacerbated by fluctuations in the value of retirement assets that, in recent years, have coincided with cyclical movements in the labor market.

This article is the first to evaluate how retirement decisions are affected by both labor market and asset shocks simultaneously. Displaced workers retire on average 14 months earlier than they would normally, had they not lost their jobs. In the meantime, negative shocks to assets delay retirement from the labor force. I estimate that the cohort of workers who were approaching retirement at the onset of the Great Recession would have tended to stay in the labor force approximately five months longer in response to the joint impact of changes in the value of household assets and the probabilities of losing and finding a job. Assuming the same cohort was affected by the labor market conditions alone, their retirement would have occurred approximately one and a half months later had they not experienced either labor market or asset shocks.

The article also makes an important methodological contribution. Introducing labor market frictions into a life cycle model of labor supply, I show that involuntary job loss is a major retirement channel. Without search frictions, the model overestimates the rates of employment among 70-year-old workers by 8 percentage points. At this age, this is an understatement of retirement prevalence of 14%. In a frictionless environment, most of this difference is absorbed by the fixed cost of work. The fixed cost of work generates sharp retirement in many models, including that of French and Jones (2011). Rogerson and Wallenius (2013) argue that its typical estimated values are unrealistically high and lack solid economic interpretation. With search frictions, I increase the share of retirements that can be explained without relying on fixed cost by approximately 10 percentage points.

My results stem from a dynamic programming model of optimal consumption and labor supply decisions with costly job search. The model includes uncertainty about survival, health status, medical expenses, asset returns, wages, and availability of jobs. It accounts for Social Security rules, Medicare, employer-provided health insurance, government transfers, unemployment insurance, taxes, and intentional bequests. The structural framework allows me to isolate the effect of layoffs, job finding, and asset dynamics on the labor supply decisions of older workers. It also helps to define a relevant reference group for studying displaced workers. Varying the probabilities of job loss, job finding, and asset returns, I account for the cyclical movements in the labor market along with the dynamics of the housing and stock prices. I estimate the model with the method of simulated moments (MSM) using data from the HRS.[3]

This article is related to several strands in the literature. Most importantly, it builds upon earlier work on retirement from the labor force within the life cycle framework, including Blau and Gilleskie (2006, 2008), French and Jones (2011), Gustman and Steinmeier (1986), Haan and Prowse (2010, 2014), Rust and Phelan (1997), Scholz et al. (2006), and van der Klaauw and Wolpin (2008). I extend the results in this literature by incorporating exogenous layoffs, search frictions, and time-varying asset returns. None of these previous papers accounts for the possibility of involuntary job loss followed by endogenous costly search. Adding these features, I address an entirely new set of questions about retirement behavior.

Next, I contribute to the literature focused on the economic cost of job loss (Farber, 1993; Jacobson et al., 1993; Stevens, 1997; Couch and Placzek, 2010; Davis and von Wachter, 2011). This literature does not accommodate endogenous retirement and produces mixed conclusions

[3] The HRS is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan.

on the relationship between age and the cost of displacement. I fill this gap by providing a detailed account of the cost of involuntary job loss for an older workforce. A small number of papers evaluate the impact of layoffs on the employment of older workers (Chan and Stevens, 2001, 2004; Elder, 2004). My estimated probabilities of postdisplacement employment rates are consistent with Chan and Stevens (2001). However, I evaluate a broader range of displacement consequences, most importantly the economic cost of job loss over the business cycle and its sources. I also model a number of features that were not addressed in these other papers, yet are essential to retirement behavior, such as health and unemployment insurance, medical expenses, Social Security take-up, and the dynamics of the labor and financial markets. Although Chan and Stevens (2004) found that pension-related incentives can only explain a small part of the observed changes in the timing of retirement associated with job loss, I show that postdisplacement wage drop and search frictions can account for a large part of the response.

Finally, there is literature that analyzes the dynamics of retirement over the business cycle. Coile and Levine (2011a, 2011b), Goda et al. (2011), and McFall (2011) implement a reduced-form approach to study retirement during recessions. Gustman et al. (2010) estimate the impact of the stock market decline on retirement using a life cycle model; however, they disregard the role of the labor market shocks. In contrast to the existing work, my model quantifies independent and combined long-term effects of wealth changes, layoffs, and job finding on the labor market behavior of older workers.

The rest of the article is divided into seven sections. Section 2 provides the essential data facts on job loss and retirement. In Section 3, I develop the life cycle model with labor market frictions. Section 4 describes the data set used in the structural estimation, and explains the choice of the estimation sample and initial conditions. Section 5 contains the details of the MSM and its implementation, as well as the estimation methods used to specify exogenous probability transitions and the policy environment. Section 6 discusses the estimates of the structural parameters. Section 7 summarizes the results based on the counterfactuals and policy experiments. Section 8 concludes the article.

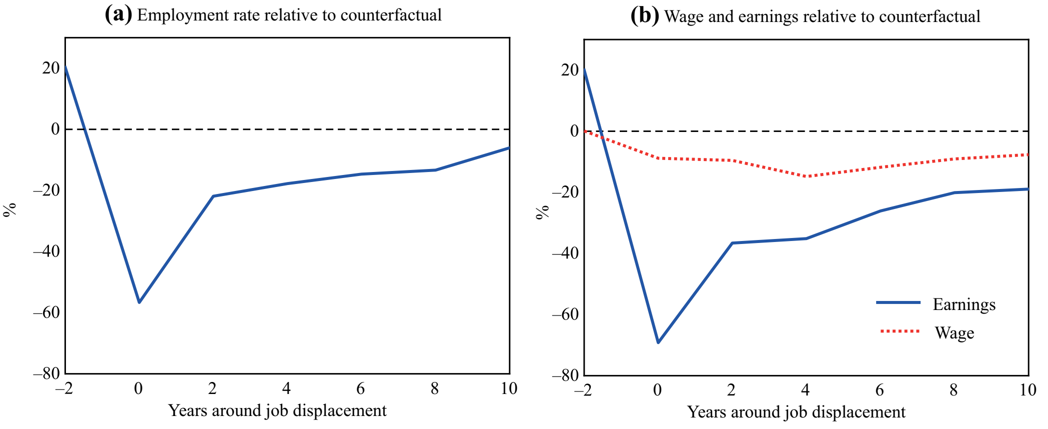
2. FACTS ABOUT JOB LOSS AND RETIREMENT

I motivate the article by highlighting the key facts on displacement and labor force attachment in the HRS, a nationally representative panel of individuals over the age of 50. I document the prevalence of layoffs among older workers and estimate reduced-form relationships between involuntary job loss, employment, and earnings.[4] The data analysis is based on employment histories of males between the ages of 50 and 80 that I construct using biennial data on their labor force status as well as employment changes reported between the survey waves.

The definition of involuntary job loss in this article is based on self-reported reasons of employment termination. Involuntary job loss is represented by two of the separation reasons included in the HRS questionnaires, "laid off/let go" and "business closed." All other separation reasons, including quit, health, family, new job, retirement, or financial incentives, are classified as quits. The data set contains information on 3,093 layoffs that represent 30% of all reported separations. According to this definition, involuntary job loss is quite common among older workers, with one in six survey respondents having been laid off at least once.

This number should be treated as a lower bound because of possible misreporting of the separation reasons that have been documented in the literature. For example, Poterba and Summers (1984) found that 25% of the Current Population Study (CPS) quits were reported as layoffs in the following survey month. Although the HRS only asks about the separation reason for each completed job spell once, adverse employment changes that frequently precede quits suggest that some of them are not easy to distinguish from layoffs. Roughly 12% of the recorded

[4] The terms layoff, job loss, and displacement are used interchangeably throughout the article. The intended meaning is best described as involuntary separation that is initiated by the firm instead of the worker, as opposed to a quit.



NOTES: The figures show percentage difference between employment rate, earnings, and wages of laid off workers and the corresponding outcomes of counterfactual workers who did not experience involuntary job loss. The estimation sample is the HRS males age 50–80, 1992–2014. Details of the estimation procedure are provided in Online Appendix A.

FIGURE 1

EMPIRICAL RESPONSE OF EMPLOYMENT, EARNINGS, AND WAGES TO INVOLUNTARY JOB LOSS [COLOR FIGURE CAN BE VIEWED AT WILEYONLINELIBRARY.COM]

quits have been encouraged by coworkers or happened in anticipation of layoff, reduction in wages or hours, or similar circumstances. Taking such instances into account, I conclude that up to 30% of the respondents may have experienced involuntary separations.

The response of older workers to involuntary job loss increasingly differs from that of the general population as their employment horizon shortens in anticipation of retirement. Approximately a quarter of the HRS displaced respondents are never reemployed, and those who are take 1.8 times longer than nondisplaced older workers to find a new job. To illustrate the relationship between job loss and the labor market outcomes of older displaced workers, I follow the literature on job displacement (Jacobson et al., 1993; Davis and von Wachter, 2011; Jarosch, 2015) and estimate a set of reduced-form statistical models that quantify the impact of involuntary job loss on postdisplacement earnings, employment, and wages. The main findings from these regressions are graphically summarized in Figure 1. Details of the methodology and complete estimation results are provided in Online Appendix A.

The left panel of Figure 1 plots the estimated postdisplacement employment rate relative to the employment rate of counterfactual nondisplaced workers over 10 years after job loss. In the year of involuntary separation, the employment rate falls by 57%. Two-thirds of the initial losses are recovered within two years, but then the recovery slows down. An employment gap of 13% persists after eight years. It finally closes 10 years after displacement, in part as both displaced and nondisplaced workers keep on retiring from the labor force. The right panel of Figure 1 plots analogous results for earnings, which also fall sharply immediately after displacement and show little improvement beyond the first two years of recovery. Unlike employment, earnings do not recover fully and remain almost 20% lower than the counterfactual even 10 years after displacement. The wage loss remains stable over a 10-year period and, on average, constitutes 9% of the counterfactual.

These estimates imply that over their remaining lifetime displaced workers on average spend 13 months less in employment. Assuming a discount rate of 4%, earnings losses of displaced workers over a 10-year period amount to 28% of the present discounted value of their earnings, which is equivalent to 1.09 of their annual predisplacement earnings. The model developed in this article quantitatively matches these reduced-form relationships and demonstrates how the estimates of the fixed effects displacement regressions are affected by selection bias. It also takes the analysis further by answering a range of questions that cannot be addressed within a regression setting.

The gap between the estimated earnings and wage losses suggests that both the wage drop and job market frictions contribute to the total cost of job loss. In addition, these two channels interact with the process of asset accumulation and individual responses to the wealth shocks and interest rates changes. Since the job search process, observed postdisplacement wages, labor supply, and saving are jointly endogenous, we cannot quantify the relative importance of these forces within a reduced-form regression framework. These dynamic decisions reflect individual expectations, which are best understood in the context of a structural model. Consequently, in the rest of the article, I develop and estimate a dynamic model of retirement with endogenous job search, labor supply, and asset accumulation. I then use the model to quantify the contribution of the labor market conditions to the cost of job loss and to disentangle the impact of the labor market and asset shocks on the retirement decisions.

3. MODEL OF LABOR SUPPLY, SEARCH, AND RETIREMENT

I now develop a dynamic life cycle model of labor supply and retirement with search frictions and stochastic returns on assets. The model describes the decision problem of an older worker who faces uncertainty about available employment opportunities, wages, asset returns, health, medical expenses, and survival. In each period of life, individuals make decisions on their labor supply, consumption and savings, job search and the take-up of Social Security. The model incorporates essential Social Security rules, taxes, unemployment insurance, government transfers, Medicare, and intentional bequests. It accounts for individual heterogeneity in terms of the lifetime earnings, year of birth, the risk of layoff, and access to health insurance. The model provides a salient framework to analyze the impact of job loss and volatility of asset returns on the labor market behavior of older workers. I proceed with a discussion of the key elements of the model.

3.1. *Preferences.* The time period in the model is equal to one month. Each month, an individual aged $t = t_0, t_1 \dots, t_T$ derives utility from consumption C_t and leisure L_t. Individuals belong to different types τ^i determined by the year of birth, lifetime earnings, the risk of being laid off, and access to employer-provided health insurance. The within-period utility function is nonseparable in consumption and leisure as in French and Jones (2011),

$$U(C_t, L_t) = \frac{1}{1-\theta_2} \cdot \left(C_t^{\theta_1} L_t^{1-\theta_1} \right)^{1-\theta_2}. \tag{1}$$

Parameter $\theta_1 \in [0, 1]$ is the weight placed on consumption, and $\theta_2 \geq 0$ determines the degree of risk aversion.

Individuals face exogenous mortality risk. An agent at age t survives to age $t+1$ with probability $\pi_t(H_t, \tau^i)$ that depends on age, health H_t, and individual type τ^i. Everyone dies with probability 1 upon reaching the terminal age t_T. Individuals who die leave all remaining assets as a bequest to their heirs. The value of a bequest in the amount A_t is determined by a bequest function

$$b(A_t) = \frac{b_1}{1-\theta_2} \cdot (b_2 + A_t)^{\theta_1(1-\theta_2)}. \tag{2}$$

This formulation has been derived as a reduced form of an altruistic bequest motive in the overlapping generations model by Abel and Warshawsky (1988) and later used to study saving decisions of the elderly (e.g., De Nardi, 2004; De Nardi et al., 2010). The coefficient $b_1 \geq 0$ captures the strength of the bequest motive, whereas $b_2 \geq 0$ characterizes the curvature of the bequest function and determines the extent to which bequests are luxury goods.

3.2. *Time Constraints.* The quantity of consumed leisure depends on the amount of labor hours N_t supplied out of a fixed endowment $L > 0$, the fixed cost of work, health, and the cost of job search:

$$L_t = L - N_t - (\phi_0 + t \cdot (\phi_1 + \psi \cdot \mathbb{1}\{H_t = 0\})) \cdot \mathbb{1}\{N_t > 0\} - \varrho \cdot s_t. \tag{3}$$

The two indicator functions denote bad health status ($H_t = 0$) and labor force participation ($N_t > 0$), respectively. The job search decision, $s_t = \{0, 1\}$, assigns the value 1 to actively searching individuals and 0 to everyone else. The time constraints (3) state that the maximum amount of leisure equals the entire time endowment, which is further reduced depending on labor supply, job search, and health status.

First, the leisure of employed individuals is decreased by the number of hours worked and the fixed cost of work. The fixed cost of work is a linear function of age, $\phi(t) = \phi_0 + \phi_1 t$, with nonnegative intercept and slope, $\phi_{0,} \phi_1 \geq 0$. Next, work requires more effort of individuals with serious health problems. Hence, those who stay employed in spite of illness lose additional $t\psi$ hours of leisure a month. Finally, unemployed individuals looking for work ($s_t = 1$) have to sacrifice ϱ hours a month to search-related activities. These are their search costs.

3.3. *Budget Constraints.* Individuals collect taxable income Y_t from wage earnings, Social Security, and unemployment benefits:

$$Y_t = N_t \cdot W_t \cdot \left(1 - d_1 \cdot \ell_t\right) \cdot \left(1 - d_2 \cdot \mathbb{1}\{N_t < 120\}\right) + SSB_t\left(T_t^a, \tau^i, \tau^{ss}\right) + B_t. \tag{4}$$

Wage earnings are determined by the wage rate W_t and the hours of labor supply N_t. The binary indicator of layoff status $\ell_t = \{0, 1\}$ takes a value of 1 if a worker has ever been laid off from a job and 0 otherwise. The wages of displaced workers are permanently reduced by a factor $d_1 \in [0, 1]$. This reduction is interpreted as a loss of human capital or obsoleteness of skills that caused a layoff. If a worker chooses part-time employment, his hourly wage rate is decreased by a factor $d_2 \in [0, 1]$. This parameter accounts for an empirical pattern of part-time workers earning substantially less than comparable full-time workers after adjusting for the number of hours worked.

The size of the Social Security benefits, $SSB_t(\cdot)$, is calculated based on the age at the time of take-up T_t^a, individual type τ^i, and parameters of the Social Security system τ^{SS}. Eligible individuals who apply draw a constant stream of benefits until death. Unemployment benefits B_t are limited to the actively searching unemployed. In the model, unemployment benefits are assigned conditional on search with probability $\lambda_B \in [0, 1]$ to avoid keeping track of the unemployment durations that would be computationally infeasible.

The assets A_t of an individual belonging to type τ^i are invested at the rate of return r_{t,τ^i} that varies over time. The rate of return depends on the type of worker and accounts for the structure of portfolios held by investors in different income brackets. No borrowing is allowed, $A_t \geq 0$. The budget constraint is

$$A_{t+1} = A_t + y(Y_t + r_{t,\tau^i} \cdot A_t, \tau) + G_t - M_t(H_t, I_t, \tau^i) - C_t, \tag{5}$$

where function $y(\cdot, \tau)$ gives after-tax income for a tax code τ and $G_t \geq 0$ is government transfers. $M_t(\cdot)$ is out-of-pocket medical expenses that depend on health, access to health insurance I_t, and individual type. The budget constraints (5) state that the value of assets in the period $t + 1$ is determined from the previously accumulated assets A_t augmented by the total value of the current period's after-tax and nontaxable income, net of expenditures on consumption and health care.

In the data, assets are measured with an error ε_t^a that reconciles the model output with observed individual decisions:

$$\widehat{A}_t = A_t \cdot \exp(\varepsilon_t^a), \qquad \varepsilon_t^a \sim N(0, \sigma_{\varepsilon^a}^2). \tag{6}$$

The government provides a minimum consumption level $\underline{C} > 0$ through transfers G_t according to the rule

$$G_t = \max\{0, \underline{C} - [A_t + y(Y_t + r_{t,\tau^i} \cdot A_t, \tau) - M_t(H_t, I_t, \tau^i)]\}, \tag{7}$$

as in Hubbard et al. (1995). For those receiving government transfers, after-tax income in this formulation reduces the amount of government transfers dollar for dollar. Individuals must totally deplete personal assets before gaining access to the consumption floor provided by the government, and the entire amount of received transfers must be consumed in the current period. Government transfers in the model serve as an aggregate approximation for all public transfer programs other than unemployment insurance and Medicare.

3.4. *Retirement Channels.* Empirically, most cases of retirement from the labor force take the form of discontinuous transitions from full-time employment to nonwork. A standard life cycle model with continuous hours of labor supply cannot capture these transitions because workers smooth their consumption and leisure over time and retire by gradually reducing their hours of work. In this article, several mechanisms jointly generate sharp retirement from the labor force, which is consistent with the data.

The first mechanism is represented by the fixed cost of work and the cost of ill health that operate through the time constraints. As workers grow older and their health deteriorates, they have to give up increasing amounts of their leisure endowment to stay employed, which results in sharp transitions from work to retirement. In addition, retirement is generated by nonlinearities in the budget constraints created by the Social Security and Medicare policies. Wages, which decrease with age to reflect declining productivity, also contribute to retirement through the budget constraints. Finally, sharp retirement is generated by the labor market frictions. This last channel, first proposed here, distinguishes this article from the rest of the literature.

3.5. *Recursive Formulation.* The vector of state variables S_t for an individual of type τ^i alive at age t includes the wage rate, medical expenses, health status, and assets. The state is also described by the employment and search decisions made in the previous period, the age of Social Security take-up, job offer indicator $\omega_t = \{0, 1\}$, layoff experience, the drawing of unemployment benefits, and the history of shocks to the labor markets and asset returns:

$$S_t(\tau^i) = \left(W_t, M_t, H_t, A_t, N_{t-1}, s_{t-1}, T_{t-1}^a, \omega_t, \ell_t, B_t, \{\lambda_{k,\tau^i}, \delta_{k,\tau^i}, r_{k,\tau^i}\}_{k=t_0\ldots t}\right). \tag{8}$$

Given the current state, an individual makes decisions D_t about the levels of consumption and savings, labor supply, job search, and take-up of Social Security. The vector of decision variables is $D_t(S_t) = (C_t, N_t, s_t, T_t^a)$. The number of labor supply hours is $N_t = 0$ for nonworkers, and $N_t \cdot s_t = 0$, which rules out on-the-job search.

Timing in the model is as follows: In the beginning of each period, an individual can be working, unemployed and looking for work, or out of the labor force. All individuals, regardless of their labor force status, start the period by receiving two exogenous shocks that determine their state of health and medical expenses. Because of the large spread of treatment costs for various conditions with similar overall impact on health, two persons in the same state of health may face very different medical expenses. Even in the case of the same diagnosis, the cost of care may be different depending on the provider, for example, primary physician compared to an emergency room. Hence, the health shock determines the mean of medical expenses through the state of health, whereas a separate medical expenses shock generates variance that is high enough to match the data.

Employed individuals receive another type-specific shock that destroys their jobs with probability $\delta_{t,\tau^i} \in (0, 1)$. Workers who did not lose their jobs then obtain updated information on their wages. In the meantime, nonemployed individuals get wage offers with probability

$$\lambda_{t,\tau^i}(s_t) = \begin{cases} \lambda^n_{t,\tau^i} \in (0,1) & \text{if } s_t = 0 \\ \lambda^u_{t,\tau^i} \in (0,1) & \text{if } s_t = 1 \end{cases}, \tag{9}$$

where $\lambda^u_{t,\tau^i} > \lambda^n_{t,\tau^i}$ are job finding probabilities for the unemployed and nonparticipating, respectively. Although the model, in principle, allows for getting an offer without searching, the chances are much smaller than when an effort is put into searching for employment opportunities. In addition, only the unemployed who were searching for jobs in the previous period may receive unemployment benefits with probability λ_B. Once the wages are revealed, workers who retained their jobs or received new offers make labor supply decisions.

Workers who just lost their jobs or quit, unemployed who did not receive acceptable offers, and workers who have been out of the labor force decide whether they want to invest time in looking for work. If they decide to search, they start the next period as active unemployed, have a higher chance of receiving a job offer, and may retain their unemployment benefits. Otherwise they enter the next period being out of the labor force.

Next, all individuals make decisions on the Social Security application, collect income, pay medical expenses and taxes, enjoy leisure, consume, and save. Finally, they receive survival shocks and either move to the next period or die and leave bequests.

In each period and state S_t, an individual chooses a decision rule D_t to maximize discounted expected lifetime utility subject to the exogenous processes for mortality, employment, health, medical expenses, and wage determination, as well as a set of time and budget constraints (3) and (5), the government transfer rule (7), and policies for taxes, unemployment benefits, and Social Security. The discount rate for future payoffs is β. The values of states with and without a wage offer, V^w_t and V^n_t, are defined recursively. The value of a state with a wage offer contains four additive terms: the current utility from consumption and leisure and the expected present values of unemployment in the case of layoff, employment if not affected by job loss, and the utility of a bequest if the worker does not survive to the next period:

$$\begin{aligned} V^w_t(S_t, D_{t-1}, \theta) = \max_{D_t} \Bigg\{ & U_t(S_t, D_t, \theta) \\ & + \beta \cdot \Bigg[(1-\pi_t) \cdot \Bigg(\delta_{t,\tau^i} \int V^n_{t+1}(S_{t+1}, D_t, \theta) \cdot p(dS_{t+1}|S_t, D_t, \theta_p) \\ & + (1-\delta_{t,\tau^i}) \int V^w_{t+1}(S_{t+1}, D_t, \theta) \cdot p(dS_{t+1}|S_t, D_t, \theta_p) \Bigg) + \pi_t b(A_{t+1}) \Bigg] \Bigg\}, \end{aligned} \tag{10}$$

where $\theta = \{\theta_s, \theta_p\}$ is a vector of model parameters that includes parameters of the state transition probability function θ_p and structural parameters θ_s. Similarly, the value of a state without a wage offer, V^n_t, is

$$\begin{aligned} V^n_t(S_t, D_{t-1}, \theta) = \max_{D_t} \Bigg\{ & U_t(S_t, D_t, \theta) \\ & + \beta \cdot \Bigg[(1-\pi_t) \cdot \Bigg(\lambda_{t,\tau^i}(s_t) \int V^w_{t+1}(S_{t+1}, D_t, \theta) \cdot p(dS_{t+1}|S_t, D_t, \theta_p) \\ & + (1-\lambda_{t,\tau^i}(s_t)) \int V^n_{t+1}(S_{t+1}, D_t, \theta) \cdot p(dS_{t+1}|S_t, D_t, \theta_p) \Bigg) + \pi_t b(A_{t+1}) \Bigg] \Bigg\}. \end{aligned} \tag{11}$$

Because the model does not have a closed-form solution, the decision rules that it generates must be found numerically. I use backward induction to solve the value functions at monthly time intervals. In estimation, the terminal age is set to 100, the maximum working age to 75, the starting ages to the age of each type in 2000, and part-time work is under 120 hours per month.[5] I estimate the structural parameters of the model using the MSM.

4. DATA

I estimate the model using the HRS, HRS RAND data set (version P), and the restricted HRS data on earnings records from the Social Security Administration (SSA). I extract the variables from 12 waves of the HRS that cover a period from 1992 to 2014 at biennial intervals. In this section, I describe the sample and variables and explain how I use the data to draw initial conditions for the structural estimation of the model.

4.1. *Sample Construction and Variables.* The estimation sample consists of white non-Hispanic males aged 50 and older. I further restrict the sample to moderate the diversity of paths that respondents may take within the system of Social Security benefits. First, I drop individuals who started receiving Social Security before turning 62 as well as beneficiaries of the Supplemental Security Income and Social Security Disability Insurance (SSI/SSDI). These conditions aim to exclude workers with disabilities who may have quite different health transition processes, access to health insurance, and nonlabor income. Second, I eliminate anyone with a total employment record of under 10 years or who has over 10 years of work in the government. These respondents would either not qualify for Social Security, which requires 10 years of contributions, or would have access to the government pension schemes that are not modeled in the article. The sample resulting from these restrictions contains information on 9,402 individuals, or 56,848 person-year observations.

To estimate the processes that govern the state transition probabilities, I use information on labor supply, wages and average lifetime earnings, assets, mortality, health, medical expenses, and health insurance. Except for the average lifetime earnings and information on layoffs, all variables are taken from the HRS RAND file. The monetary values are converted into constant 2000 dollars. The SSA data allow me to compute the average lifetime earnings. In addition, I construct a proxy of the SSA's average indexed monthly earnings (AIME) by indexing wages to the year 2000 and taking an average of the top 35 values, which are replaced by zeroes if not enough years were reported. Indexing is done with the national wage index. I impute the missing values of medical expenses, average lifetime earnings, and wages using a regression-based procedure (David et al., 1986).[6]

Labor supply is computed as a product of the usual hours of work in a week and the average number of weeks in a month. Search decisions are constructed from information on the current labor force status and questions about job search activities. Layoff incidents and the calendar months in which they occur are extracted from self-reported employment histories and separation reasons, as described in Online Appendix B.1. Assets are measured as the net value of the financial and housing wealth of the household. They account for the value of housing, vehicles, businesses, ownerships in Individual Retirement Accounts (IRAs), financial instruments, and investment funds, and other savings and debt. Assets do not include the value of pensions. I discuss the implications of this restriction in Online Appendix B.2.

Health status is a binary variable based on the question that asks respondents to evaluate their own health on a five-point scale as excellent, very good, good, fair, or poor. I define health

[5] Setting the maximum working age reduces the dimensionality of the problem. Only 10% of the HRS estimation sample are employed after 75, and less than 3% hold full-time jobs.

[6] The fractions of the imputed values of medical expenses and lifetime earnings that are used in the computations are 2.8% and 2.5%, respectively. Missing earnings data arise because administrative records are only available for about three quarters of the respondents.

status as good for the top three categories and bad otherwise. Medical expenses are individual out-of-pocket payments for health care. These expenses include the cost of stays in hospitals and nursing homes, visits to doctors and dentists, outpatient surgery, prescription drugs, home health care, and special facilities paid by the respondent in a two-year reference period. They do not include expenses covered by health insurance, but do include insurance premiums paid by the respondent.

Access to health insurance is described by a categorical variable that takes three values: health insurance provided by the current or previous employer to respondents under 65, respondents older than 65 covered by Medicare, and respondents younger than 65 not insured by their employer. The last category involves individuals without any health insurance (61%) as well as those insured by privately purchased plans (39%). Both groups pay higher medical expenses on average, either as insurance premiums or as a direct cost of health services. I exclude from the estimation of state transition probabilities for medical expenses individuals whose only insurance comes from their spouses' employers or government plans other than Medicare, such as Medicaid, CHAMPVA, and TRICARE. These respondents together account for 3.6% of the estimation sample, with the largest share (3%) made up of those insured through their spouses' employers.

4.2. *Individual Heterogeneity and the Initial Distribution of State Variables.* To estimate the structural parameters of the model, I only use eight waves of the HRS data covering the period from 2000 to 2014. Earlier waves are excluded because of the changes in the Retirement Earnings Test that took place in 2000 and substantially changed the policy environment for employment decisions of older workers. I draw initial conditions for the joint distribution of state variables from a sample of individuals born between 1938 and 1943. The model starts in 2000 when these respondents were between 57 and 62 years old. After accounting for missing data, these restrictions leave 422 individuals with complete information available in 2000 who are eligible for initial state draws. A larger sample of 1,120 individuals with 5,450 available person-year observations is used to compute the moments matched in the estimation.

The model distinguishes between 36 individual types. Each type is defined by the year of birth, position in the distribution of earnings, and the risk of being laid off. The six birth year types are essential in establishing the age of laid-off workers at different stages of the business cycle. They form the basis of inference on the impact of cyclical fluctuations in the asset values, job loss, and job finding probabilities on the labor supply of older workers as they approach retirement. Three earnings types are defined by the AIME tertiles. Two layoff risk types, low and high, are identified based on the HRS question that asks respondents to evaluate the likelihood of losing a job within a year. I predict the likelihood of a layoff from a regression of self-reported probabilities on the individual characteristics. An individual is assigned to a high-risk type if predicted probability exceeds 0.5 and to a low-risk type otherwise. It has been shown in the literature that job loss expectations have a high predictive power for actual job loss (Stephens, 2004). Accordingly, my risk indicator appears to be a valid predictor of the actual layoff experiences. The monthly probability of a layoff in the estimation sample is 0.001 for the low-risk type and 0.003 for the high-risk type, a statistically significant difference. The fractions of workers who have experienced job loss in the two groups are 0.132 and 0.293, respectively.

The initial joint distribution of ages, assets, wage rates, AIME, health, medical expenses, health insurance, labor supply, and layoff risk for 10,000 simulated workers is drawn from the 2000 HRS data set using individual sampling weights. I assume that the initial state summarizes all relevant information from earlier ages and that it does not reflect any anticipation of future changes to the policy environment, such as reforms of the Social Security or the tax code. Drawing initial conditions from the data accounts for some important empirical relationships between the variables of the model, as reflected in Table 1. The table summarizes descriptive statistics for the initial state distribution. For example, the risk of layoff and the rates of unemployment are highest for the low-income type, a correlation essential for the conclusions of the article. Individuals with higher lifetime income understandably hold more assets and

TABLE 1
DESCRIPTIVE STATISTICS FOR THE INITIAL STATE DISTRIBUTION

Variable	Income Type 1	Income Type 2	Income Type 3
Fraction in good health	0.81	0.87	0.95
Fraction working	0.84	0.81	0.87
Fraction unemployed	0.03	0.02	0.01
Fraction at high risk of layoff	0.49	0.53	0.39
Fraction with employer-provided health insurance	0.58	0.73	0.83
Labor supply (conditional on employment), in hours per month			
Mean	180	180	188
Median	160	160	180
Standard deviation	55.1	69.8	70.0
Wage rate (conditional on employment), in 2000 dollars			
Mean	21.4	34.0	38.2
Median	11.5	15.9	15.0
Standard deviation	18.3	35.4	36.6
AIME, in 2000 dollars			
Mean	1,789	3,464	4,878
Median	1,877	3,452	4,793
Standard deviation	684	379	541
Assets, in thousands of 2000 dollars			
Mean	309	428	704
Median	143	215	394
Standard deviation	493	520	838
Monthly medical expenses, in 2000 dollars			
Mean	55.3	82.5	63.9
Median	27.2	27.1	32.0
Standard deviation	87.1	204.9	128.2
Mean age, years	59.3	59.9	59.6
Sample observations	140	132	150

NOTES: HRS white non-Hispanic male workers born in 1938–1943 with at least 10 years of nongovernment employment. Excludes early recipients of Social Security (before 62) and recipients of SSI/SSDI. Income types 1–3 correspond to the tertiles of the AIME distribution.

earn higher wages. The initial state also reflects a complicated connection between financial well-being and health. Workers of the highest income type are healthier and pay higher out-of-pocket medical expenses while being more likely to hold jobs with employer-provided health insurance. Heterogeneity in the layoff exposure accounts for the important fact that low-skilled workers are more likely to lose their jobs.

5. ESTIMATION METHODS

I estimate the model parameters in two stages similar to Gourinchas and Parker (2002), De Nardi et al. (2010), and French and Jones (2011). First, I obtain the values of the parameters determining exogenous probabilities of transition between the points of the state space that can be identified without using the entire model, θ_p. This estimation stage yields the transition processes for health, survival, medical expenses, wages, job loss and job finding, and asset returns. At this stage, I also set up the policy rules for taxes, Social Security, and unemployment insurance.

Second, I use the MSM (McFadden, 1989; Pakes and Pollard, 1989; Gouriéroux and Monfort, 1996) to estimate the structural parameters of the model, while taking the first-stage estimates as given. The vector of $m = 14$ parameters obtained at the second stage, $\theta_s \in \Theta$, includes the coefficients of the utility and bequest functions, the fixed costs of work, health and search costs, wage losses due to human capital depreciation and part-time employment, government transfers, leisure endowment, the probability of getting unemployment benefits, and the variance of measurement error in assets:

$$\theta_s = \{\theta_1, \theta_2, b_1, b_2, L, \phi_0, \phi_1, \psi, \varrho, d_1, d_2, \underline{C}, \lambda_B, \sigma^2_{\varepsilon^a}\}. \tag{12}$$

The parameter space $\Theta \subset \mathbb{R}^m$ is restricted to account for the lower and upper feasibility boundaries of the parameter values, as dictated by the model.

I exploit five groups of moments for each age between 60 and 70. These are the rates of employment conditional on health, the fraction of part-time workers among the employed, the means of monthly labor supply, the rates of job search among the nonparticipating, and the quartiles of the asset distribution. In addition, I match the variance of assets and the mean length of an unemployment spell, yielding 90 moment conditions in total.

Technical details of the estimation procedure are provided in the appendices. Online Appendix C describes the estimation of processes for health and wage transition probabilities. Online Appendix E provides a more detailed description of the MSM estimation. I limit discussion in the rest of this section to the main aspects of the policy environment and aggregate uncertainty.

5.1. *Job Finding and Layoff Probabilities.* The job finding probabilities rely on the gross flows of workers between labor force states. The gross flows are obtained from the rotating part of the basic CPS on males aged 50 and above.[7] The probability that a worker unemployed in month t will become employed within one month is used as the job finding probability for actively searching individuals. The probability of transition from nonparticipation to employment is used as the job finding probability for those who do not search.

Layoff probabilities are computed from the HRS retrospective job histories. I adjust the monthly layoff probabilities by a factor of 1.3 for workers at high risk of layoff and by a factor of 0.5 for workers at low risk. Adjustments are based on the differences of job loss probabilities of layoff risk types in the data, so that the weighted average for the two types is consistent with the overall probability of involuntary job loss.

I employ 12-month centered moving averages as job finding and layoff probabilities in the model for the months with available data, 2000–2015. Beyond this period, I converge the values to their sample averages over a period of three years. The mean values of the estimated series are $\lambda = 0.23$ and $\delta = 0.004$. Both probabilities for older workers are lower than their counterparts for all ages. This is consistent with other studies documenting that mobility between labor force states declines with age (e.g., Menzio et al., 2015).

5.2. *Asset Returns and Discounting.* The annual discount rate for future payoffs β is set equal to 0.96. Workers invest their wealth in housing, stock, and an additional composite asset. The share of wealth invested in each asset depends on the worker's income type. Workers of higher income type tend to hold more wealth in stock, whereas housing is the main asset for those with a low lifetime income. Because of such variations in the portfolio structure, any shocks to the housing or stock markets would impact individuals with various levels of wealth differently. I obtain the net values of housing, direct stock holdings, and IRA from the HRS RAND data on the composition of assets. Stock holdings reflect both direct stock ownership and the share of IRA invested in stocks, and I take the share of stocks in the IRA from Gustman et al. (2010). Using these data, I compute the share of each asset in a typical portfolio held by workers of different income types.

The return on portfolio is the weighted average of returns on individual assets. The rate of return on stocks is approximated by returns on large company stock (Ibbotson et al., 2017).

[7] I use the CPS for job finding and the HRS for layoff probabilities. The CPS gives more accurate information on monthly labor force status and has a larger sample size. Unfortunately, it does not have data on separation reasons for workers who have left the labor force, making it unusable for the estimation of involuntary separation rates among older workers who often leave the labor force in response to a layoff.

Housing appreciation is based on the FHFA all-transactions index. All returns are 12-month moving averages of the original series adjusted for inflation. Annualized rate of return on other assets is 4%, and the portfolio returns converge to the 4% rate over three years after the end of the observed series.

Asset returns, the probability of job finding, and the probability of layoff are the three sources of aggregate uncertainty in the model. Workers are fully rational and form their expectations of the labor and financial markets based on the least squares forecasts from a linear vector autoregression model of order 3, as supported by the data.

5.3. *Government.*

5.3.1. *Social security.* The model incorporates three major features of the Social Security policy. First, awarded benefits are determined from the primary insurance amount (PIA), a transformation of the AIME over two bend points defined by the SSA. Second, the benefits are subject to the lower and upper limit. Finally, there is a penalty for Social Security take-up before the normal retirement age. The earliest Social Security eligibility age is 62, and the normal retirement age of the simulated cohorts varies between 65 and 66. Since the model does not offer incentives for delayed retirement, I assume that everybody applies for Social Security upon reaching the normal retirement age. I incorporate these rules into the model with parameter values varying by year of birth. The exact policy rules, institutional details, and the values of the parameters used in the simulations are described in Online Appendix D.

5.3.2. *Taxes.* Individuals pay federal, state, and payroll taxes. I take the federal tax rates from the annual tax rate schedules, head of household tables.[8] The state tax rates are taken from 2001 Rhode Island tax rates schedule.[9] Earnings are subject to Social Security and Medicare payroll tax at a rate of 7.65% up to a year specific maximum. Earnings above this maximum are taxed at a rate of 1.45%, which only covers Medicare's Hospital Insurance.[10] The Social Security benefits of early retirees may be taxed in accordance with the Social Security Earnings Test (SSET) as described in Online Appendix D.

5.3.3. *Unemployment insurance.* The amount of unemployment benefits is set to replace 50% of predisplacement earnings with a maximum of 1,300 dollars per month. The maximum value roughly corresponds to the state average published by the U.S. Department of Labor in 2001 "Comparison of State Unemployment Laws." According to the same source, between January 2000 and December 2014, the average duration of unemployment benefits was 3.8 months. The estimated probability of unemployment benefits reward targets this average.

6. BASELINE ESTIMATES OF THE STRUCTURAL PARAMETERS

In this section, I discuss the estimates and explain how each structural parameter is identified from the data. Furthermore, I show how the model fits the data and highlight the role of search frictions, a new modeling component that is central to the main contribution of the article.

6.1. *Estimates and Identification.* Table 2 contains the MSM estimates of the model parameters and the standard errors. I discuss each estimate below relative to the benchmarks available in the literature and explain the identification strategy.

[8] Source: http://www.irs.gov/pub/irs-prior/i1040–2005.pdf

[9] Ideally, I would like to use state tax rates for the respondent's state of residence. Unfortunately, I do not have access to the HRS state identifiers, so I have to impose a uniform state tax. I chose Rhode Island because it was one of the last states to abandon piggyback taxes in 2001. It gives me a straightforward way to estimate tax liability based on federal taxes. French and Jones (2011) claim it to be a fairly representative state in terms of income tax rates.

[10] Source: http://www.ssa.gov/oact/progdata/taxRates.html

TABLE 2
ESTIMATES OF THE STRUCTURAL PARAMETERS

Parameter	Estimate	Standard Error
θ_1: Consumption weight	0.536	0.035
θ_2: Coefficient of relative risk aversion	4.93	0.180
b_1: Intensity of bequest motive	1.008	0.098
b_2: Bequest shifter	1.084	0.204
L: Monthly leisure endowment, hours	364	22.1
ϕ_0: Fixed cost of work at 60, hours	59.8	2.69
ϕ_1: Fixed cost of work, slope	0.089	0.026
ψ: Cost of bad health, hours	0.186	0.027
ϱ: Cost of search, hours	108	25.3
d_1: Wage loss due to displacement	0.150	0.013
d_2: Wage loss due to part-time employment	0.294	0.027
$\underline{C}$: Government transfers, USD	345	9.78
λ_B: Probability of getting unemployment benefits	0.850	0.128
$\sigma^2_{\varepsilon^a}$: Variance of the measurement error in assets	0.205	0.010
χ^2 statistic = 485, degrees of freedom = 76		

NOTES: Method of simulated moments estimates of the structural parameters, conditional on exogenous estimates of the state transition probabilities. Initial values of the state variables are drawn from the 2000 HRS sample of white non-Hispanic males 50 and older with at least 10 years of nongovernment employment, born in years 1938–1943. Excludes early recipients of Social Security (before 62) and recipients of SSI/SSDI. Estimation uses diagonal weighting matrix.

Individual preferences are characterized by the parameters of the Constant Relative Risk Aversion utility and bequest functions. The consumption weight, $\hat{\theta}_1 = 0.54$, reflects the relative tastes for leisure and consumption, with higher values implying stronger preference for work. It is identified primarily from the hours of labor supply. The estimate is within the interval obtained by French and Jones (2011) for the different values of willingness to work index, $\theta_1 \in [0.412, 0.967]$. The coefficient of relative risk aversion for a consumption–leisure bundle, $\hat{\theta}_2 = 4.9$, is consistent with the life-cycle retirement literature, for example, French and Jones (2011) and French (2005). Under the assumption of fixed labor supply, this estimate translates into the coefficient of relative risk aversion for consumption $R(C) = 1 - \hat{\theta}_1(1 - \hat{\theta}_2) = 3.1$, a conventional measure that is easy to compare to the broad labor supply literature. The coefficient of relative risk aversion is identified by the asset quartiles that reflect the extent of precautionary savings accumulated to insure against adverse income and health shocks.

The parameters of the bequest function are identified from the upper quartiles of the asset distribution. In the data, wealthier individuals keep on saving instead of divesting even after they have accumulated sufficient assets to insure against the risks incorporated into the model environment. The presence of an altruistic bequest motive generates this behavior in the model. At the terminal age $t = t_T$, the bequest motive becomes operational once the level of assets reaches the threshold

$$A_b = \hat{b}_2 \left(\frac{\hat{b}_1}{\hat{L}^{(1-\hat{\theta}_1)(1-\hat{\theta}_2)}} \right)^{\frac{1}{\hat{\theta}_1(1-\hat{\theta}_2)-1}},$$

which, after adjusting for the scaling of the coefficients, gives a value of 23,000 dollars. This is the minimum amount of savings an agent needs to leave a nonzero bequest to a heir instead of consuming the entire amount himself. This amount is low enough to suggest that at the terminal age, the bequest motive is operational for the majority of workers. The marginal propensity to consume out of the final period wealth is one for individuals whose assets are below this threshold, and $MPC = dC/dA = 0.02$ for those who hold more. Analogous relationships can be derived for other ages; hence, the maintained level of saving at the top of the wealth distribution and the rate of saving among those whose assets are above the operational bequest threshold jointly identify the intensity of the bequest motive $\hat{b}_1 = 1.008$ and the bequest shifter $\hat{b}_2 = 1.081$.

The monthly time endowment, L, is 364 hours, identified by the employment and labor supply moments. The fixed cost of work for a 60-year-old worker is 60 hours per month. The estimated slope of the linear fixed cost function suggests that the monthly fixed cost of work increases by approximately one hour over a year. Although my model yields approximately the same monthly fixed cost as French and Jones (2011) for a 60-year-old worker, the age trend is substantially smaller.[11] The explanation comes from the introduction of labor market frictions in my model, and I discuss it further in Subsection 6.3. The fixed cost parameters are identified by declining trends in the participation rates and labor supply. The additional cost of work caused by ill health is 0.2 hours per month. This parameter is identified by the rates of labor force participation conditional on health status. The estimated cost of the search parameter is 108 hours per month, implying that looking for work takes about the same time as half-time employment. Identification of the search cost is based on the search intensity moments.

Together these estimated parameters of the utility function and the time constraint capture the way in which workers intertemporally substitute their labor supply. For example, Frisch intertemporal elasticity of substitution for a healthy 60-year-old worker employed $N_{60} = 160$ hours a month would be approximated by

$$\eta = \frac{\hat{L} - N_{60} - \hat{\phi}(60) - \hat{\psi}}{N_{60}} \cdot \frac{1 - \hat{\theta}_1(1 - \hat{\theta}_2)}{\hat{\theta}_2} = 0.567,$$

assuming that the borrowing constraint is not binding. This value falls just above the middle of the interval between 0.37 and 0.70, which, according to Chetty et al. (2011), defines the range of the microestimates for Frisch intensive margin elasticity.

Turning to the parameters of the budget constraint, the most important is the wage loss associated with displacement. It is estimated as 15% of the wage received by otherwise similar nondisplaced workers. The cost of search and wage loss is identified by the share of nonworking individuals who look for work at each age and by the variation of job finding probabilities across time. The estimate is close to several reference points available in the displacement literature. For example, Couch and Placzek (2010) estimate the mid-term wage losses of displaced workers six years after separation in the range of 13%–15%. Similarly, Davis and von Wachter (2011) find that displaced workers in the United States lose 10%–20% of their earnings in the long term depending on whether separation occurred during an expansion or a contraction.

If displaced workers who obtain good wage draws are more likely to stay in the labor market after job loss, wages observed in the data will be biased upward. The model predicts that one year after job loss, wages of reemployed workers will be 14% lower than their counterfactual wages if job loss does not occur. However, the wage loss estimated from the simulated data by the fixed effects displacement regression in Section 2 is only 9%. This implies that the standard displacement regressions prevalent in the existing literature may underestimate wage losses of reemployed workers by as much as one-third and even more when we consider all workers affected by displacement.

The premium for full-time employment, d_2, is 29% of the wage rate. This parameter is identified by the rate of part-time employment, and the value is consistent with the 25% part-time employment penalty found by Aaronson and French (2004). The monthly government transfer $\underline{C} = \$345$ is identified by lower asset quantiles because the guaranteed consumption minimum discourages saving among the poor. In annual equivalent, it is on the same scale as the consumption floor in Hubbard et al. (1995).

[11] The annual fixed cost of work at age 60 in French and Jones (2011) is $\phi_{P0} = 826$, and the age trend is $\phi_{P1} = 54.7$ hours.

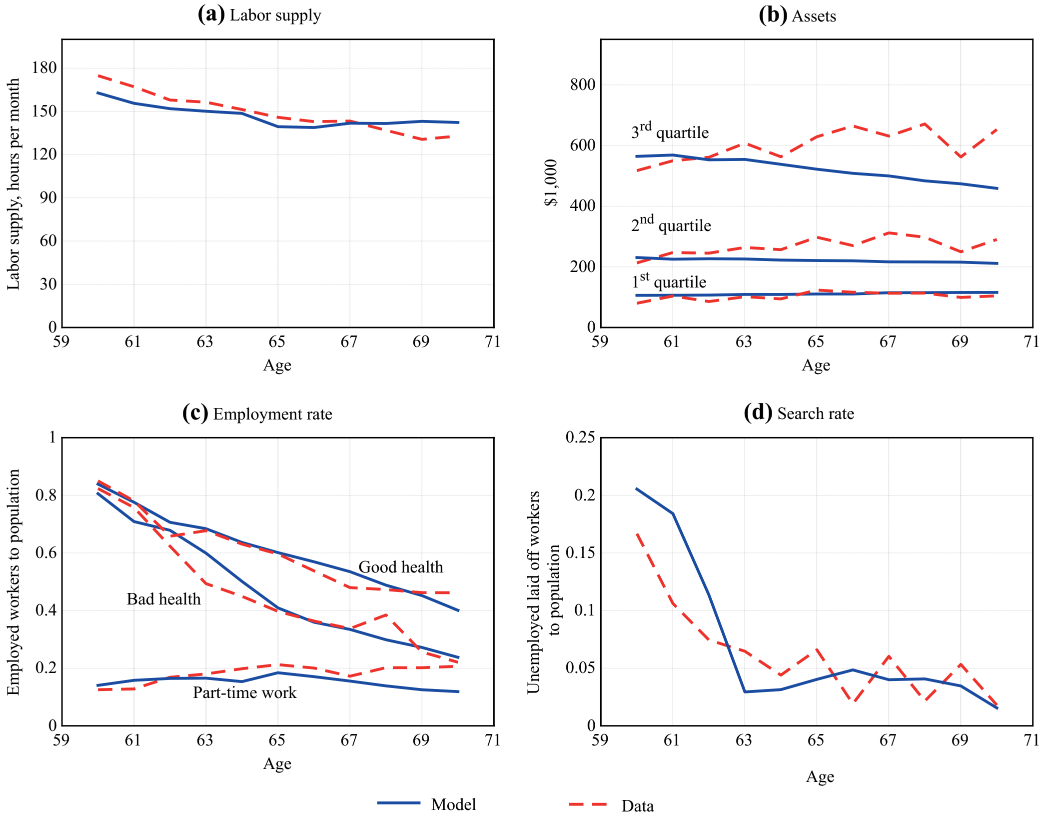


FIGURE 2

MODEL FIT: MATCHED MOMENTS [COLOR FIGURE CAN BE VIEWED AT WILEYONLINELIBRARY.COM]

6.2. *Model Fit.* Figure 2 shows the model fit for matched moments. I further provide some results to check whether the model captures some of the data facts that were not directly used in the estimation. The model predicts well the number of workers affected by layoffs over their lifetime and the difference in the timing of labor force exit for displaced and nondisplaced workers. Conforming with the data, the share of workers who retire after a layoff grows steadily until peaking at age 65. The model also reproduces the matrix of transitions between labor force states with an exception of exit rates from unemployment that are somewhat lower than in the data.

6.3. *The Role of Search Frictions.* The life-cycle models of retirement from the labor force typically ignore search frictions, allowing for no job destruction and costless access to positive draws from the wage distribution. Usually, under these assumptions, the transition from work to retirement is driven by changes in wage and nonwage income, health, government policies, or fixed cost of work. I show that search frictions represent an additional incentive to exit the labor force, accounting for up to 20% of retirements. Hence, the omission of these labor market frictions results in a nontrivial bias. To show how search affects the model predictions and estimates, I revert to a standard life-cycle retirement model by assuming that jobs are always available ($\lambda_{t,\tau} = 1$) and never destroyed ($\delta_{t,\tau} = 0$), search is free ($\varrho = 0$), and there is no unemployment insurance ($\lambda_B = 0$). I compare the original model and the frictionless one in two experiments.

In the first experiment, I assume that the labor markets are frictionless and use the estimated model parameters to create a simulated data set. The employment rate of workers who have reached their normal retirement age in this simulation is on average 5 percentage points higher than in the data. The fraction of workers retired by the age of 70 is underestimated by 8 percentage points, which is 14% of the retirement prevalence at this age. These differences are substantial and indicate that, without search, a model of retirement would have to overload other channels to match the data.

In the second experiment, I estimate a frictionless model and identify the parameters that turn out to be the most sensitive to the omission of search. I find that the main change occurs in the fixed cost function, increasing the fixed cost of work for a 65-year-old worker by 70%. This result appeals to earlier discussions of the role of fixed costs. Rogerson and Wallenius (2013) estimate that the time fixed cost required to generate sharp retirement from the labor force for acceptable values of the intertemporal elasticity of substitution of labor supply exceeds the time required to hold a half-time job. This is implausibly high, and my experiment indicates that one reason is that the fixed costs absorb the role of other retirement incentives that were omitted from the model. By introducing labor market frictions, I explain a portion of this excessive fixed cost, which is an important methodological contribution.

7. DISCUSSION AND COUNTERFACTUALS

I now use the model to analyze the impact of involuntary job loss on the labor market outcomes of older workers. Taking full advantage of the structural approach, I construct counterfactual life paths of twin workers who are identical in all initial characteristics and received shocks, except that one of the twins is displaced at some point in his life, whereas the other is not. Comparison of the outcomes of these twin workers over the life cycle yields a flexible tool helpful to evaluate a wide range of job loss consequences.

First, I estimate the impact of involuntary job loss on the labor force attachment of older workers and validate the model by comparing its results to the corresponding estimates of displacement regressions. Next, I compute the cost of displacement in terms of a cash transfer required to compensate a displaced worker for the total lifetime utility loss caused by a layoff, a broader measure than the earnings cost of job loss that is often used in the displacement literature. I further decompose the total cost of job loss into two components that are associated with the labor market frictions and postdisplacement wage penalty.

Because the incidence and the cost of displacement are both related to the probabilities of losing and finding a job, I consider in a separate section how the cost of job loss and postdisplacement labor force attachment vary over the business cycle. Finally, I show how the labor market conditions interact with the asset shocks affecting the retirement of displaced workers. To illustrate this point, I estimate the effect of the Great Recession on the retirement decisions of workers who have reached their late fifties by the beginning of the economic downturn.

7.1. *Labor Force Attachment after Involuntary Job Loss.* To begin with, I show how displacement affects the labor force attachment and the timing of retirement. I take a sample of older workers and simulate their behavior in several different scenarios. In the baseline scenario, workers never lose their jobs even though they anticipate such a possibility when making their decisions. In each of the displacement scenarios, workers are laid off at a specific age that ranges between 58 and 70. In all scenarios, apart from job loss, workers receive the same shocks. Therefore, their simulated histories completely coincide with the baseline scenario up to the age of layoff, and any differences after that age are solely ascribed to the job loss. The comparison of the levels of labor supply chosen by workers under the baseline and displacement scenarios shows how labor force attachment is affected by job loss.

Involuntary job loss, on average, decreases the lifetime labor supply of displaced workers by 2,100 hours, an equivalent of one year's full-time work. Reaching 14 months over their lifetime, the reduction of labor supply following displacement is even larger on the extensive margin. This indicates that displaced workers decrease their labor supply on the extensive as well as intensive margins. Indeed, two years after job loss, displaced workers are two and a half times more likely to work part time, and 28% less likely to hold a job than if they had maintained steady employment. These results are consistent with the reduced-form estimates discussed in Section 2. The employment loss in the displacement regressions is 13 months, and the reduction of the employment rate two years after displacement is 35%. Because the MSM estimator did not target any moments that characterize the labor supply response to job loss, comparability of these results is essential for model validation.

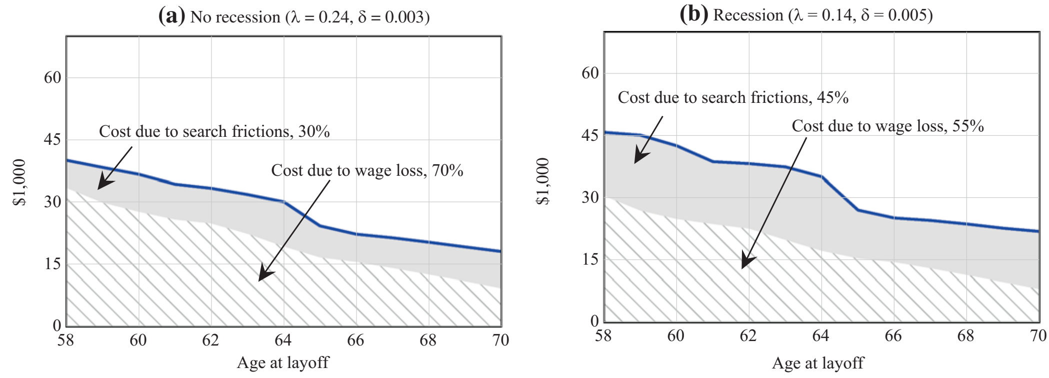
Finding that job loss is associated with early retirement is consistent with earlier studies (e.g., Chan and Stevens, 2001). However, looking beyond the averages reveals the existence of a sizable group of individuals who respond to job loss by working more in the years following displacement. One in six laid-off workers would increase their lifetime labor supply by an average of 2,460 hours, or 14 months in full-time equivalent.

The labor supply response to job loss varies because the choice of retirement time may mitigate the displacement cost in two different ways. On the one hand, early retirement eliminates the need of costly job search. A worker whose expected benefits from finding a job are lower than the expected cost of search would benefit from retiring early. On the other hand, delayed retirement can help recover retirement savings used up during an unemployment spell. The cases of delayed retirement are mainly linked to the interaction between retirement assets and expected future earnings. Displaced workers on average reach the age at which they would have otherwise retired with lower assets than if they had not been displaced, as they would have withdrawn some funds to finance consumption while unemployed. Some of the workers with better wage offers at hand will find it optimal to stay employed and replenish savings. In the simulated data, workers who delay their retirement earn substantially higher predisplacement wages. Layoffs therefore have a differentiated impact: They are more likely to drive low-income workers out of the labor market while making higher wage earners stay longer.

Because responses to layoffs vary, displacement outcomes in the economy depend on the composition of the affected workers. For example, if job loss only affected low-wage earners in the bottom 10% of the wage distribution, then most of the displaced workers would retire at the same time or earlier and only 11.6% would delay retirement from the labor force. However, if affected workers were concentrated in the median 20% of the wage distribution, the rate of delayed retirement would rise to 14.5%. It would further increase to 27.7% if the top 20% of wage earners lost their jobs. The composition of workers affected by layoffs has been changing over time and is likely to change again in the future. For example, the Great Recession has pushed an unprecedented number of white collar workers into unemployment. This analysis shows how the impact of job loss on the transitions from work to retirement depends on the composition of the older workforce and the possible concentration of layoffs in specific industries or occupations.

7.2. *The Cost of Job Loss.* There is ample evidence that displaced workers suffer from a broad range of negative consequences of job loss, including earnings and employment instability, deteriorating health, an increase in mortality, and adverse effects on family, such as higher divorce rates and lower educational achievement of the children (Davis and von Wachter, 2011). Here, I measure the cost of job loss for older workers as a monetary transfer required to make a displaced worker indifferent between his current state and otherwise equivalent state in which he was not laid off from a job.

Although a large part of the cost of job loss can be traced to forgone earnings, the full cost is substantially more complicated than the change in the lifetime earnings alone. On the one hand, the full cost amplifies earnings losses by adding nonmonetary costs of job loss, including time costs incurred while looking for a new job, the increasing difficulty of working late in life due to the age trends in health and fixed costs of work, disruption of health insurance, and costs associated with nonlinearity of the preferences. On the other hand, it accounts for the ability of workers to partially offset the cost of job loss by adjusting their labor supply,



NOTES: The cost of layoff is computed as a monetary compensation required to keep a worker indifferent between the states of displacement and nondisplacement. The solid line shows the total cost of layoff by age of job loss. The height of the dashed area corresponds to the cost of job loss due to the reduction of the wage rate. The height of the shaded area shows the cost of job loss due to search frictions.

FIGURE 3

THE COST OF LAYOFF BY AGE OF JOB LOSS
[COLOR FIGURE CAN BE VIEWED AT WILEYONLINELIBRARY.COM]

consumption, and Social Security take-up decisions. Overall, this measure is broader and more comprehensive than the earnings cost of job loss that is conventionally used in the displacement literature.

Panel A of Figure 3 shows the estimated cost of job loss for each age of layoff between 58 and 70 when the probabilities of job loss and job finding are fixed at their long-term averages. On average, the lifetime cost of job loss for workers displaced at these ages amounts to 29,000 dollars, which is about one year of earnings for this age group. The cost of job loss declines with the age of displacement, and the Social Security rules appear essential to understanding this dynamics. Workers displaced in their late fifties bear the highest cost, losing around 40,000 dollars over their remaining lifetime: 40% more than the average. The cost of job loss falls with the approach of early retirement age, so that workers displaced at 62 lose 17% less than if they had lost their jobs four years earlier. The cost of job loss does not change much until the full retirement age, when it falls sharply by an additional 23% relative to the cost of job loss for 58-year-olds. It remains consistently high, around 20,000 dollars, even for workers in their late sixties.

To understand the link between the cost of job loss and the Social Security retirement age, we have to recall the previously documented spikes in the rates of the labor force exit at the early and full retirement ages (e.g., Rust and Phelan, 1997). At any age, involuntary job loss is not going to affect the lifetime outcomes of a worker who intended to retire exactly at this age regardless. A mass of workers who plan to leave the labor force around early and full retirement ages will therefore lower the average cost of displacement at these ages. The expected remaining working time of those who reached retirement age is shorter, both because these workers are now older and because they have an option to take up Social Security. The shortening of expected employment time prevents the cost of job loss from increasing again after passing the peaks of retirement. Of course, lower averages do not mean that specific individuals are better off being displaced around the normal retirement age, as in each case, the cost of job loss would depend on the anticipated individual retirement date that may be well past the Social Security age.

To see what generates the cost of job loss, it should be noted that displaced workers are adversely affected via two channels. First, they suffer a permanent reduction in future wages. Second, they lose earnings and access to health insurance due to search frictions. The two channels represent both the intensive and extensive margins of the cost associated with job loss, respectively, and can be explored separately. The intensive margin can be closed by eliminating the displacement wage penalty ($d_1 = 0$), whereas the extensive margin is removed under the assumption of frictionless labor markets ($\lambda_{t,\tau} = 1$ and $\varrho = 0$).

Decomposing the total cost by channel, I find that in stable economic conditions, most of the losses are due to the reduction of postdisplacement wages (intensive margin), which accounts for 70% of the total. The remaining 30% is due to the loss of earnings over the periods of unemployment that follow a job loss (extensive margin). The share of the extensive margin depends on the age of displacement, as shown in Figure 3. Search frictions are relatively more important for workers laid off around the normal retirement age, due to the increasing number of displaced workers who give up potential earnings by retiring early without attempting to search. The fraction of costs due to job search peaks at a displacement age of 64, where it accounts for more than a third of the total.

7.3. *Job Loss over the Business Cycle.* The probabilities of job loss and job finding vary over the business cycle, and their dynamics affect both the incidence and the cost of job loss. In this section, I repeat a set of experiments similar to those from Subsections 7.1 and 7.2 to estimate the impact of job loss in a recession on the labor force attachment and the cost of displacement.

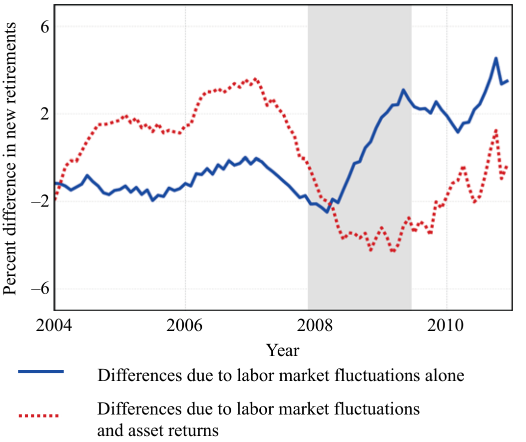
Workers displaced during a recession face lower probability of job finding and higher chances of repeated displacement. I set the recessionary probabilities of job finding and job loss equal to the estimates obtained at the trough of the Great Recession ($\lambda_{\text{rec}} = 0.14$ and $\delta_{\text{rec}} = 0.005$). The benchmark probabilities remain fixed at their long-term average levels as in the previous section. A recession lasts for one year, after which job finding and job loss probabilities revert to their long-term averages.

Business cycle fluctuations exacerbate the negative impact of displacement on the labor force attachment. The lifetime labor supply of older workers displaced in a recession decreases by an additional 450 hours, or two and a half months of full time work. Accounting for the extended duration of search, their total time in the labor force is three months lower than that of the identical workers displaced in more favorable economic conditions. Recessions further polarize the response by workers who adjust their hours of work in the opposite directions. Those who work less over their lifetime now supply 14% fewer hours, and those who work more increase the number of hours by an additional 12%. In monetary terms, these changes in the labor force attachment translate into an additional loss of 5,000 dollars over the lifetime, generated almost exclusively by search frictions, which in a recession account for 45% of the total loss (panel B of Figure 3).

Not only do displaced workers lose more if laid off during a recession, but more displacements also occur in a weak economy. What is the overall impact of an economic downturn, like the Great Recession of 2007–2009, on the labor force attachment of workers who would have been planning to retire around this time? To answer this question, I consider an artificial cohort of workers whose age is between 57 and 62 at the end of 2004, just over three years after the trough of the previous recession in November 2001. When the new recession ensued three years later in December 2007, those workers (aged 60–65 by that time) would be hit directly in the process of transition to retirement.

To estimate the impact of the recession on the retirement behavior of this cohort, I simulate two data sets. In the first simulation, the probabilities of layoff and job finding are fixed at their long-term averages. The second simulation uses the actual job finding and layoff probabilities registered between the beginning of the simulation period in December 2004 and December 2010, a year and a half after the trough of the Great Recession. This experiment introduces labor market cyclicality into the environment of older workers as they transition to retirement. Comparing labor force transitions in the two data sets, I can now discern how the rates of exit from the labor force vary at different stages of the business cycle.

The solid line in Figure 4 represents the percentage difference in the new monthly retirements observed in the simulations with the cyclical probabilities against the benchmark case that uses



NOTES: The solid blue line shows percentage difference in new retirements in simulations with actual probabilities of layoff and job finding against the benchmark case where both probabilities are set to their long-term averages: 12 months moving average of the simulated data. The dotted red line in addition accounts for percentage difference in new retirements due to the variation in asset returns. Gray areas correspond to the NBER contraction dates.

FIGURE 4

THE RESPONSE OF NEW RETIREMENTS TO THE VARIATION IN JOB FINDING AND LAYOFF PROBABILITIES [COLOR FIGURE CAN BE VIEWED AT WILEYONLINELIBRARY.COM]

the long-term averages. The positive and negative values represent higher and lower rates of retirement, respectively, relative to the stable economy scenario. As the probabilities of job loss and job finding deviate from their average values, there is substantial variation in the new retirements, with the range of changes amounting to about 7%. The number of new retirements steadily increases from the onset of the recession, with the peak difference of 4.6% reached by the end of 2010. Overall, the entire cohort retires one and a half months earlier in the recession.

7.4. *Involuntary Job Loss and the Asset Shocks.* The results discussed in the previous section show that the cyclical variations in job finding and layoff probabilities are important for retirement behavior and that more retirements occur when the labor market is weak. Another aspect of the business cycle that is highly relevant for the decision to retire is the performance of financial markets. The retirement wealth of the simulated cohort was depleted as the stock markets shrank by more than 50% over a year and a half of the Great Recession, accompanied by a comparable decline in the value of housing equity. The stock markets also fell by more than 30% during the dot-com bubble of 2000–2002. The estimates of the recession impact would therefore be incomplete without accounting for another major feature of the Great Recession, the negative shock to the returns on assets.

It is commonly acknowledged that although layoffs accelerate retirement, asset losses postpone it. For example, Coile and Levine (2011a) document how the media view of the impact that the Great Recession had on retirement evolved over time. Initially envisioning delayed retirement due to the crash of financial markets, the media later increasingly turned to the predictions of early retirement caused by unfavorable labor market conditions. As in both recent recessions, asset shocks that have affected retirement wealth coincided with the cyclical variations of job finding and layoff probabilities, the total effect of recessions on the retirement behavior of older workers is ambiguous. Using the model, I can isolate the impact of shocks that have affected asset and labor markets on retirement and the cost of job loss.

To model the financial impact of the recession on retirement, I introduce a solitary unanticipated negative shock to the value of assets and compute the resulting change in the timing of retirement. I find that the decline in asset returns, which takes place while the probabilities of job loss and job finding remain fixed at their long-term average values, indeed forces workers to stay in the labor force longer. A 20% shock to asset values on average delays retirement by four months, whereas a 50% shock produces a delay of almost one year.

Adding the asset shocks to the recession counterfactuals from Subsection 7.3, I can simulate the joint impact of layoffs and asset returns during the Great Recession. The dotted line in Figure 4 shows percentage change in new retirements during the recession once the variation in asset returns has been taken into account. The early retirement peak shifts to the left, so that workers who were not yet affected by the negative asset shocks self-select to retire just before the recession. Later on, however, more workers delay retirement from the labor force in an attempt to make up for wealth losses. With both asset and labor market dynamics taken into consideration, I find that workers who retired during the Great Recession would, on average, postpone retirement by approximately five months. Intuitively, asset losses dominate the final outcome for two reasons. First, the two forces do not entirely cancel each other out as job loss itself leads to delayed retirement for some of the displaced workers. Second, fewer people are affected by layoffs than by changes in asset returns, even when the impact of a layoff is bigger in magnitude.

8. CONCLUSION

At least one in five older workers in the United States is affected by involuntary job loss shortly before retirement from the labor force. As the probabilities of job finding decrease with age, displaced older workers experience longer unemployment spells and substantial reduction in earnings over their remaining lifetime. Faced with the difficulty of reemployment, many stop searching and permanently exit the labor force. Involuntary job loss and labor market frictions therefore potentially represent an important retirement incentive. To estimate the cost of job loss for older workers and understand its effect on the transition from work to retirement, I construct a dynamic programming model of retirement with search frictions.

I estimate the structural parameters of the model using the method of simulated moments and the data from the HRS. The model confirms that search frictions and involuntary job loss are essential to an understanding of retirement, as they account for 10 percentage points of retirements in the model. In a frictionless environment, the model predicts that the fraction of retirements otherwise explained by search is predominantly absorbed by the fixed cost of work. This result explains why the fixed costs of work are excessively high in the standard life cycle models of labor supply and retirement.

The average cost of involuntary job loss measured by the compensation required to keep a worker indifferent between the states of employment and unemployment due to displacement is equivalent to one year of full-time earnings. Seventy percent of this cost is attributed to the postdisplacement wage reduction, the rest is due to search frictions. The cost of losing a job in a contraction, with job loss and job finding probabilities equal to those observed at the trough of the Great Recession, is approximately 17% higher. This difference is mainly generated by search frictions that account for a substantially larger portion of the total cost during economic downturns.

Displaced workers on average retire about one year earlier than they would have done without a job loss. However, 18% of the simulated workers postpone their retirement in response to a layoff. The fraction of displaced workers who retire early increases during recessions when the labor market is weak. Yet, in the two most recent recessions, the negative impact of job loss on the lifetime labor supply was partially offset by retirement delay caused by a decline in savings as they were hit by the plunge of the stock markets and the housing bubble. I estimate that the simultaneous shocks to the values of assets, layoff, and job finding probabilities would lead the cohort of workers who approached retirement age at the onset of the recession to postpone retirement by approximately five months.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix A
Appendix B
Appendix C
Appendix D
Appendix E
Figure 1: The HRS questions on the labor market history of respondents between survey waves
Table A.1: Employment, earnings and wage losses of displaced workers
Table C.1: Logit estimates of survival and health transition probabilities
Table C.2: Estimates of the medical expenses process
Table C.3: Estimates of the wage transition process
Table D.1: The NRA, PIA minimum and early retirement penalty
Table D.2: Dollar amounts in PIA and maximum family benefit formulae

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