Research Division
Federal Reserve Bank of St. Louis
Working Paper Series

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Leora Friedberg
Michael T. Owyang
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Working Paper 2003-038E
http://research.stlouisfed.org/wp/2003/2003-038.pdf

November 2003
Revised July 2006

FEDERAL RESERVE BANK OF ST. LOUIS
Research Division
P.O. Box 442
St. Louis, MO 63166

Searching For Better Prospects: Endogenizing Falling Job Tenure and Private Pension Coverage*

Leora Friedberg†
Michael T. Owyang‡
and
Tara M. Sinclair§

Keywords: Pension, Contracts, On-the-job search, Job tenure, Matching models, Job-to-job flows

July 13, 2006

Abstract

Recent declines in job tenure have coincided with a shift away from traditional defined benefit (DB) pensions, which reward long tenure. New evidence also points to an increase in job-to-job movements by workers, and we document gains in relative wages of job-to-job movers over a similar period. We develop a search model in which firms may offer tenure-based contracts like DB pensions to reduce the incidence of costly on-the-job search by workers. Either reduced search costs or an increase in the probability of job matches can, under fairly general conditions, lower the value of deterring search and the use of DB pensions. [JEL Classification: E24, J32, J41, J63, J64]

*The authors wish to thank Marcus Berliant, Riccardo DiCecio, Rob Dittmar, Richard Johnson, Éva Nagypál, Stan Panis, Garey Ramey, John Stevens, Jay Stewart, seminar participants at Washington University, and participants at the North American Summer Meeting of the Econometrics Society and the American Economic Association annual meetings for helpful comments. Abbigail J. Chiodo, Kristie M. Engemann, and Xuan Tam provided excellent research assistance. The views in this paper are the authors' alone and do not reflect the views of the Federal Reserve Bank of St. Louis or the Federal Reserve System. All remaining errors are our own.

†Corresponding author. Department of Economics; University of Virginia and NBER; P.O. Box 400182; Charlottesville, VA 22904-4182. lfriedberg@virginia.edu

‡Research Department; Federal Reserve Bank of St. Louis; P.O. Box 442; St. Louis, MO 63166.

§Economics Department; George Washington University; 1922 F Street, NW; Old Main, Suite 208; Washington, DC 20052.

1 Introduction

Workers in the United States have experienced significant changes in both job tenure and the structure of employer-provided pensions over the past twenty years. Traditional defined benefit (DB) pensions, which reward long tenure, have become steadily less common, while both actual and expected job tenure have fallen over the same period. The link between job tenure and pension trends has not been closely examined but offers insights about both phenomena. This paper investigates how on-the-job (OTJ) search by workers provides a motive for the use of deferred compensation and how that motive may have changed over time.

Spurred by evidence of a long-term increase in job-to-job mobility (Stewart, 2002), we show that relative wages of job-to-job movers have increased as well. These trends suggests that OTJ search has been associated with improving match quality over time. To explore these features, we develop a model in which workers may search for new, more productive matches while on the job. A key element of the model is that both OTJ search and the resulting quits are costly to the firm. We show conditions under which the firm, to avoid this loss, might offer a contract that dissuades workers from searching. The contract takes the form of delayed compensation that is conditioned on the worker not quitting. These contracts look much like DB pensions. In a recent paper, Friedberg and Owyang (2002, hereafter FO) argued that the value of long-term jobs has fallen, which has reduced expected job tenure and undermined the effectiveness of DB pensions at deterring moral hazard. This paper pursues a related line of research, incorporating a more realistic representation of job search and thus highlighting another change in the nature of long-term jobs.

In our framework, an increase in the gains from OTJ search caused by, for example, lower search costs, results in more search, more quits, and consequently shorter job tenure, all of which undermine the incentive to offer pensions. Moreover, increased OTJ search is predicted specifically for workers in more productive matches, which fits with our evidence that relative wage changes of job-to-job movers have improved. The model thus emphasizes an endogenous shift in the use of pensions, as opposed to exogenous changes resulting from new government regulations that have been highlighted in the pension literature. Also, in contrast to FO where the decline in job tenure and DB pension use results from an increase in endogenous match destruction, we consider the role played by increased *voluntary* worker flows, which are involuntary to the firm.

This paper draws on research in several areas. The model is motivated by the increasing importance of job-to-job flows by workers and their potential role in helping to explain declining job tenure. An obvious candidate to explain increased job-to-job flows is a decline in search costs, associated most recently with the explosion of internet use and perhaps over a longer period with structural shifts in the economy.[1] We recognize the difficulty, however, of finding enough data to know why job-to-job flows increased and job tenure declined, so as an alternative we develop a model of OTJ search as a way to explore possible explanations. These efforts follow a thread of the search literature in which a reduction in search frictions is generally predicted to increase the productivity range over which agents search, thus raising job-to-job flows (Pissarides, 2000) and reducing average job tenure.[2] The greater incentive to search diminishes the effectiveness of pensions in deterring search – thus linking recent trends in job tenure and pension structure.[3]

This paper also extends the literature focusing on DB pensions as incentive contracts, built on work by Lazear (1986). Notably, this paper complements other recent work incorporating tenure-based contracts that deter OTJ search (Burdett and Coles, 2003; Stevens, 2004). The essential similarity of those two papers and ours is that a worker in a job may choose not to seek outside offers if the firm offers a rich enough incentive, for example by

[1] For example, local labor markets may have changed so that workers with given skills have more firms to match within a particular location. This may be a consequence of trends like the shift into services and out of manufacturing, in which firms tend to be local monopsonists; of rising urbanization and resulting agglomeration economies, either within or across industries (Glaeser et al., 1992); and of reductions in communication and transportation costs, which increase the gain to decentralizing production (Gersbach and Schmutzler, 2000).

[2] If the matching function exhibits increasing returns to scale (evidence of this was reported by Sato, 2001), then developments like these will have a magnified effect in raising matching efficiency and hence the gains to search.

[3] This emphasis complements recent papers that explore conditions under which reductions in search frictions undermine long-term relationships (Ramey and Watson, 2001; McLaren and Newman, 2002; Matouschek, Ramezzana, and Robert-Nicoud, 2006).

tying compensation to tenure, even though productivity need not rise with tenure. The papers differ in the details of search and match formation, which determine the particular costs and benefits of search. Both Stevens and Burdett and Coles assumed that firms post wages for jobs in which productivity is known in advance and workers choose among jobs offering differing starting points on the tenure-based wage profile. Job offers arrive costlessly, but workers are less likely to quit the higher they are on the wage profile. Firms face a tension between starting workers at a lower point on the wage profile and raising current profits, or at a higher point and raising retention rates and future profits.[4] In Stevens, firms post not a wage but a contract taking the form that all pay is deferred until a date T agreed to at the outset. In Burdett and Coles, workers are risk-averse, so firms offer a contract with rising wages.

In comparison, our model simplifies some aspects of job markets in order to expand on others. Instead of posted contracts for jobs with known productivity, we assume bargaining after risk-neutral agents meet and get a permanent productivity draw. That draw determines whether the worker accepts the match and, in addition, a pension contract to forgo OTJ search. In our case, search is costly, which explains why (as in the real world) only some and not all workers search OTJ. We also assume that a firm cannot post a vacancy while a worker occupies the job, and that a firm faces uncertainty in the value of future matches. The resulting costs of search borne by firms motivate the firms to discourage workers from searching. Compared to the papers by Burdett and Coles and by Stevens, we offer a more stylized contract. The contract consists of wages determined by Nash bargaining, together with a lump-sum paid out to the worker in the event that a match ends exogenously but forfeited if the worker quits.[5]

Besides incorporating asymmetries in the costs and benefits of search, another key contribution that we make is to analyze changes in the economic environment that undermine tenure-based contracts. While the papers by Burdett and Coles and by Stevens concentrate on proving the existence of the tenure-based contract in the steady state, we emphasize the

[4] The starting point on the wage profile is heterogeneous across firms since they differ by size (as they can hire more than one worker) and by productivity (in Stevens).

[5] We prove that such a contract are feasible, while the other papers proved that the contracts are optimal.

fragility of the contract in response to plausible changes in the economic environment. Our hypothesis of an endogenous motive for the shift in pension structure also contrasts with the pension literature that focuses on exogenous changes in federal regulations. The shift in emphasis here suggests the possibility that regulatory changes *responded to* an underlying increase in the gains to worker mobility.

The paper is organized as follows. In Section 2, we discuss trends in private pension coverage, job tenure, job-to-job flows, and job search costs. We also present evidence that wages of people moving job-to-job rose over time, relative to wages of both people staying in the same job and people starting a new job after a spell of unemployment. In Section 3, we present the baseline model with OTJ search. In Section 4, we introduce the pension contract which may prevent OTJ search. In Section 5, we show how a reduction in the cost of OTJ search or a decline in the matching rate may render some pension contracts infeasible. Section 6 concludes.

2 Background on Worker Mobility and Pensions

In this section, we discuss trends in job tenure and private pensions. We then present evidence from others about the incidence of on-the-job search and job-to-job flows, which are important in magnitude, and about trends in search and job-to-job flows. Lastly, we present data that we have constructed to analyze wage changes associated with job-to-job flows.

2.1 Trends in job tenure

Over the last 20 years, both actual and expected job tenure have fallen. Expected tenure data are noisier than actual tenure data but show a greater decline. Average current tenure of male full-time employees aged 22-59 in the Survey of Consumer Finances fell from 9.2 in 1983 to 8.6 years in 2001, while expected remaining tenure fell from 18.0 in 1983 and 15.9 in 1992 to 13.7 in 2001.[6] Changes in job tenure among women reflect a combination

[6] See FO for more details. Since the mid-1990s, researchers have found mounting evidence of a decline in male job tenure in the Current Population Survey (Neumark, Polsky, and Hansen, 1999; Bureau of

of cohort-specific increases in labor force attachment and secular declines in job tenure. Average current tenure of female full-time employees rose from 7.2 years in 1983 to 7.9 years in 1992 and then fell back to 7.1 in 2001, while expected remaining tenure fell from 15.3 in 1983 to 13.6 in 1992 and then 12.3 in 2001.[7] Adding together current and expected remaining tenure yields subjective estimates of total expected job duration. For men, total expected tenure fell from 27.2 years in 1983 to 24.4 years in 1992 and 22.3 years in 2001, a 18.0% decline overall and an 8.6% decline since 1992. For women, expected tenure fell by 13.3% overall and by 9.5% since 1992.

A decline in expected remaining job tenure may indicate increased expectations of either voluntary or involuntary job changes. We do not have evidence about whether the rate of voluntary quits has risen. However, Farber (1997) noted that the decline in job tenure in the CPS was not matched by an increase in layoffs, indicating that increases in mobility are to some extent voluntary. In any case, a perceived increase in the risk of involuntary job loss should induce more on-the-job search as well.

2.2 The structure of private pensions

At any given time, over half of all full-time workers in the U.S. have pension coverage in their current job, and a greater number have been in a job with a pension at some point.[8] Fundamental differences in the structure of pension plans affect the incentive to stay in a particular job. DB plans discourage mobility for many years after a worker starts a job, while DC plans are largely tenure-neutral. While the specific parameters of DB plans vary across employers, the path of pension wealth accrual in a typical DB plan is characterized by sharp spikes, as in Figure 1.[9] Allen, Clark, and McDermed (1988) estimated that the

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Labor Statistics, 2000), the Panel Study of Income Dynamics (Jaeger and Stevens, 1999), and the National Longitudinal Surveys (Bernhardt et al., 1999), although not the Survey of Income and Program Participation (Gottschalk and Moffitt, 1999). Other researchers have not investigated data on expected tenure as we have. Tenure trends tended to flatten beginning around the mid-1990s in the SCF and CPS, but residual tenure has declined steadily if we control for business cycle effects.

[7] The wording and organization of questions regarding future work plans was different enough that the 1983 SCF may not be comparable to later years.

[8] The rate of pension coverage in the current job among full-time employees declined a little from 67% in the 1983 SCF to 58% in 1998.

[9] Pension wealth in year t is the actuarially discounted real present value of expected pension benefits if the job ends at year t. Pension wealth accrual is the discounted change in pension wealth if the worker stays another year and then leaves. Figure 1 shows pension wealth accrual in two plans from the Health

pension loss associated with switching jobs for the average worker with a DB plan aged 35-54 was approximately half a year's earnings. The smooth path of DC pension wealth accruals, which consist of contributions to an account and accumulated returns, as shown in Figure 1, stands in stark contrast.

Workers have experienced a major shift in pension coverage in the last twenty years. Among full-time employees with a pension in the SCF, 69% had a DB plan and 45% had a DC plan in 1983, while 39% had a DB plan and 80% had a DC plan in 2001 (some have both types). FO demonstrated that workers with DB pensions have longer current and expected total job tenure than workers with DC pensions or no pensions, and that the same workers are generally experiencing declines in tenure and in DB pension coverage.

In a series of papers summarized in Lazear (1986), Lazear developed models in which employers structure compensation to deter shirking by workers whose effort cannot be observed perfectly. A DB pension, whose value rises with job tenure, motivates effort by workers who do not want to get fired and lose their "bond." Early models of pensions, however, did not typically incorporate uncertainty about job duration, nor make explicit the nature of the worker's outside option. FO incorporated moral hazard in a matching model which clarifies the value of tenure-based contracts, while this paper allows workers in jobs to seek new opportunities as well, which provides another motive for pension contracts.

Recent research on private pensions has focused on changes in federal pension regulations. Regulatory changes have enhanced DB funding provisions and DC tax incentives and placed limits on the structure of DB and DC plans. FO discussed a variety of reasons why regulatory changes do not appear to fully explain the shift in pension structure. For example, pension structure has not changed uniformly in all jobs; instead, workers have moved over time from jobs that typically offer DB plans to jobs that typically offer DC plans (Clark and McDermed, 1990; Gustman and Steinmeier, 1992; Kruse, 1995; Ippolito, 1995; Papke, 1999). Also, inequality in pension coverage by skill group has increased, mirroring trends in earnings inequality that have been attributed to structural changes in the economy (Bloom and Freeman, 1992; Even and Macpherson, 2000).

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and Retirement Study (Friedberg and Webb, 2005). Spikes are generated at the vesting date and often at the plan's early and/or normal retirement dates.

2.3 Existing research on worker mobility

Data limitations severely hamper the measurement of job-to-job flows, on-the-job search, and search costs. Nevertheless, U.S. data that has become available since the mid-1990s offer several pieces of relevant evidence. First, job-to-job moves are quite important. Second, on-the-job search is common. Third, search costs appear to be declining, as, for example, internet use has expanded.

2.3.1 Job-to-job flows

In 1994, the Current Population Survey (CPS) began asking people whether they were still working for the same employer as they had been a month earlier, providing a much more accurate view of job-to-job flows than was available before. When Fallick and Fleischman (2004) used this data for 1994-2003, they found that an average of 2.6% of employed workers changed employers each month. This accounted for almost 40% of both job separations and new job starts – a major share of all labor market flows.[10] It remains difficult at this point to distinguish a recent trend from cyclical characteristics. The magnitude of job-to-job flows dipped from 1994 to 1996 and rose slowly from 1996 to 2000, then fell considerably from 2000 to 2003 during a time of labor market weakness.

Stewart (2002, 2005), recently developed a much longer series, though with a smaller sample size, based on retrospective data from the March CPS.[11] Stewart (2002) documented a major increase of 59% in job-to-job flows (defined as occurring with two or fewer weeks of unemployment) from 1975 to 2000. While the series rose early on and then fell to roughly the same level in 1982, it increased steadily afterwards, save for a dip during the economic downturn of 1989 to 1991. This was matched by a decline in job-to-unemployment flows, suggesting that workers are increasingly better at searching while on-the-job. Later, we will use Stewart's method to analyze wage changes associated with job-to-job flows.

[10] Using the CPS will still lead to an underestimate of the incidence of job-to-job flows. The CPS follows residents of the same address from month to month, rather than following the same individuals, so it misses job changes that involve a change of residence.

[11] Fallick and Fleischman discussed the drawbacks of earlier attempts to use the CPS to develop longer series of worker flows. Kambourov and Manovskii (2004) noted the difficulty of identifying *occupational* mobility using Stewart's method, arising because of high rates of error in occupational coding. We are not focusing on occupational mobility, though, so this is not of concern to us.

2.3.2 On-the-job search

In February 1995, 1997, and 1999, the CPS asked questions about on-the-job search by workers. Meisenheimer and Ilg (2000) found that, in February 1999, 4.5% of employed wage-and-salary workers had actively looked for a new job within the previous three months.[12] Fallick and Fleischman (2004) linked information on search in February 1997 and 1999 with job-to-job flows a month later and concluded that those who had actively searched for a job in the previous three months prior were much more likely to have changed jobs (11.3% versus 2.1% for non-searchers) by March – so on-the-job search is followed by job changes.

Nevertheless, it appears that traditional survey methods do not capture all forms of job search. Only about 1/5 of those who had moved from one job to another in March had actively looked for a job earlier, according to Fallick and Fleischman. A similarly low rate (about 1/3) of those who had started a new job in March after being out of work in February were classified in February as unemployed, i.e. actively searching for a job. There may be a few explanations for the apparent low rate of active job search among those subsequently starting new jobs: contacts initiated by potential employers may not be reported as active search; active search may have only taken place a few weeks immediately prior to starting a new job; and some new jobs resulting from active job search are associated with residential moves and thus not followed in the CPS. It is important to keep this in mind when considering the difficulty of measuring trends in on-the-job search.

2.3.3 Search costs and the internet

While we have no data on long-term trends in search costs, many researchers have focused on the reduced cost of conveying information brought about by the expansion of the internet since the early 1990s. The incidence of internet search is high. In the December 1998 CPS, Kuhn and Skuterud (2004) found that 7.1% of people with jobs, 15.9% of people with jobs and with internet access at home, and half of the unemployed with internet access

[12] Active job search involves contacting an employer, employment agency, school employment center, or acquaintances about a job; sending out resumes; filling out applications; checking union or professional registers; or placing or answering ads. Passive job search involves reading the want-ads or attending a job training program. The incidence of on-the-job search declined between 1995, when it was 5.6%, and 1999. It is, again, impossible to distinguish between cyclical and secular shifts in behavior with a short series.

at home used the internet for job search. The rate of internet search by those with jobs exceeds earlier estimates of on-the-job search using all other methods, as we noted above (Meisenheimer and Ilg, 2000).

Moreover, there is growing evidence of an impact on labor markets. It is many times cheaper for firms to post vacancy announcements on the internet than in newspapers (Autor, 2001), and almost all major employers now accept online job applications (Freeman, 2002). These changes may have subtler effects too; heterogeneity in the way job seekers use the internet may explain simultaneous claims that individuals who use the internet are positively selected on unobservable qualities (according to internet search firms cited in Kuhn and Skuterud, 2004) or negatively selected (a belief commonly held by employers, according to Autor). Meanwhile, Autor suggested that employers are increasingly using the internet to target employed "passive candidates"; activity of this type would help explain the increase in job-to-job flows together with the relatively low rate of job search reported by job movers.

Two recent papers attempted to estimate the causal effect of internet search on labor market outcomes, but they were limited by the scope of the available data as well as the identification strategies. Kuhn and Skuterud (2004) focused on the unemployed. They found that, after controlling for observable differences correlated with both internet use and shorter unemployment durations (like education and previous occupation), the unemployed who used the internet for job search were neither more nor less likely to be employed a year later than other unemployed. Estimates that attempted to control for unobservable differences suggested that those who used the internet may have been less likely to be employed a year later.

Stevenson (2003) documented some of the consequences of internet job search using an instrumental variable strategy. She focused on average internet penetration rates across U.S. states and found, after instrumenting, several positive and statistically significant relationships. In states with higher internet penetration, the unemployed used a greater number of types of search activities; employment-to-employment flows among more skilled workers rose; and interstate mobility rates of younger and more skilled individuals rose – all evidence that the internet facilitates job search. As Stevenson remarked, this is clearly an area that awaits further investigation in order to understand how to match theoretical concepts of job search with those that can be observed and measured.

2.4 New evidence on wages and job-to-job flows

Earlier, we discussed Stewart's new method for measuring job-to-job flows over a long period. We have extended his approach so that we can study wages associated with job-to-job flows from 1983-2001. While we cannot examine wage changes directly (since wage data is not collected in repeated months), we can compare hourly wages in a given March CPS for two groups of workers who have been continuously employed for the last 14.5 months – those who experienced a job-to-job flow relative to those who stayed in the same job continuously.[13] We make this comparison by running a regression with log hourly earnings on the left-hand side and an indicator variable on the right-hand side for people experiencing a job-to-job flow within the last year, along with controls for year, gender, education, age, and race.[14]

Our results are shown in Figures 2 and 3. The hourly wage of people in the CPS who experienced a job-to-job flow is lower throughout than the hourly wage of people staying in the same job continuously. However, Figure 2 shows a major, steady, and statistically significant decline in this relative wage gap in the 1990s, with the gap closing from -17.6% in 1992 at the end of a recession to -3.0% in 2001. Because job-to-job flows are cyclical, we went further by regressing this relative wage gap for job changers on the contemporaneous unemployment rate, with the resulting residual shown in the heavy lower line in Figure 3. Except when this cyclically-adjusted relative wage gap experienced a dip during the 1990 recession, it otherwise shrank steadily during both the 1980s (from -15.7% in 1983 to -11.6% in 1990) and the 1990s (from -13.6% in 1993 to -10.4% in 2001), declining by one-third overall.

[13] We focus on almost the same sample as Stewart, as described in the Figure 2 notes, except we include only the outgoing rotation groups, who were asked data on current hourly earnings. Our resulting sample is roughly 1/4 of the total available and ranges from 7,000-9,000 per year. While we could try computing wage changes by getting hourly earnings data for the same people a year earlier, this would involve matching across CPSs and incurring substantial attrition that is probably correlated with job changes.

[14] These demographic controls account for wage changes due to changes in the composition of the labor force. The results were virtually the same when we allowed the coefficients on the demographics to change from year to year; we report results when the covariates are held constant over the sample period. The coefficient on the relative wage of job-to-job movers is statistically significant every year, based on Huber-White standard errors.

The CPS cannot be used to make a further comparison with people who changed jobs but experienced an intervening spell of unemployment. Instead, we identify those who were in a job in March and experienced unemployment at all within the previous 14.5 months.[15] Then, we compare current wages for those experiencing a job-to-job flow with those experiencing some kind of unemployment-to-job flow (without knowing whether they began the period in a job or not). We find that the job-to-job movers experienced relative wage gains on this front as well. The lighter line near the top of Figure 3 shows the difference between residual wages, after controlling for demographics and then business cycle effects as above, of unemployment-to-job movers and of job-to-job movers. The relative wage gap for the unemployment-to-job movers rose from -4.2% in 1983 to -7.7% in 2001, relative to the job-to-job movers.

To sum up, we find that job-to-job movers experienced relative wage gains over the same period in which job-to-job flows rose and DB pension use declined. The wage gap among those who moved job-to-job within the previous 14.5 months narrowed significantly and substantially, compared to those staying in a job continuously. Moreover, the wage gap compared to those in a job but with an unemployment spell in the previous 14.5 months widened significantly.

3 The Model

Spurred by evidence of a long-term increase in job-to-job flows and of gains in relative wages of job-to-job movers, we develop a discrete time model in which workers may search for new, more productive matches while on the job. We employ a framework based on stochastic job matching with incomplete contracting.[16] Our contribution is to incorporate flows to new jobs out of employment as well as unemployment.

[15] The problem is that we cannot distinguish those who began the period in a job, became unemployed, and then got a new job versus those who were unemployed at the outset and then got a job. These two groups are probably somewhat heterogeneous.

[16] The stochastic job matching framework builds on den Haan, Ramey, and Watson (2000). Few other models combine OTJ search and match-specific productivity. Our model of OTJ search is based on Mortensen (1988) and Pissarides (1994, 2000). For a dynamic general equilibrium model with OTJ search, see Krause and Lubik (2004). For a very different model of wage bargaining with OTJ search with an emphasis on competition among employers, see Cahuc et al. (2006).

When firms cannot directly contract to prevent quits, then they may defer a portion of compensation in order to deter OTJ search. Yet, the willingness of agents to commit to a long-term contract depends crucially on the degree of uncertainty – hence the importance of assuming stochastic match draws. Because we are specifically interested in this form of compensation, we will focus almost exclusively on currently employed workers (rather than the unemployed) as we discuss the model. After developing the model, we discuss the conditions under which an increase in the expected gains from OTJ search undermines the pension contracts.

3.1 Basic framework

Timing. At the beginning of each period some firms and workers are matched, and some are unmatched. All unmatched agents begin the period in the matching pool, as do matched workers who are searching on the job. Searching workers and firms meet, draw a productivity level, and decide whether or not to produce. If they choose not to produce, they re-enter the matching pool next period. Firms and workers who have been producing exogenously separate with probability δ before they produce and cannot rejoin the matching pool in the current period. Finally, agents make their next-period search decisions, the two parties negotiate a wage, and production occurs at the drawn productivity level less any cost of search.

The matching pool. A unit mass of risk-neutral workers and a continuum of firms with discount factor $\beta < 1$ search in the labor market during a given period and meet a single agent with probability λ, which we assume for now takes a value of 1.[17] A newly matched worker and firm receive productivity $Y \in [0, 1]$, which is drawn from a cumulative distribution function $F(y)$ that is homogeneous for all new matches. They commence production if the productivity draw exceeds a reservation value or else re-enter the market to seek a new match next period.

Workers searching in the labor market may be either employed or unemployed. We

[17] For simplicity, we assume that the meeting probability λ is fixed. Given a fixed λ, then further assuming a value of 1 does not affect the basic interpretation of our results. Below, we explore the impact of $\lambda < 1$ and then an increase in λ, and we mention the implications of scale effects in the matching function.

define S as the threshold productivity level of a match above which a worker chooses not to search OTJ, so all workers currently matched at $Y < S$ engage in active job search. Workers who search while employed incur a search cost $c(Y) \geq 0$ that absorbs part of output, with $c(0) = 0$ and $0 \leq c'(Y) < 1$. Firms, though they observe workers searching, cannot search for a worker unless the position is vacant. This assumption prevents the firm from firing a worker if it were to find a more productive one and leads to an asymmetry when the worker finds a better match: The firm is indifferent as to the cause of separation but the worker is better off with a quit than a layoff.

Separation. Unlike some related models (see FO), we assume that the match-specific productivity stays fixed after it is initially drawn. We impose an alternative assumption of exogenous layoffs in order to preserve our focus on quits. Thus, matches end because of one of the following:

- *(Involuntary) Layoff.* At the beginning of the period, an exogenous shock arrives with probability δ, independent of Y. Layoff shocks are idiosyncratic and generate flows to unemployment.

- *(Voluntary) Quit.* If a worker searches OTJ and matches with a new firm, the pair draws a new level of productivity Y'. If Y' exceeds the worker's reservation productivity, the new match is established and the old one destroyed. Otherwise, the old match is preserved, and the worker and old firm continue to produce Y less the cost of search $c(Y)$.

If a separation occurs, the worker returns to unemployment and receives the outside option b^w representing unemployment benefits, home production, or leisure, while the firm receives the outside option b^f and opens a vacancy. We will assume that $b^w = b^f = 0$.[18]

Division of Output. The total value of the match depends on current output, the expected discounted stream of future production, and also the worker's decision to search or not. Current output is allocated via a wage function $\tau(Y)$ determined by Nash bargaining. The Nash bargaining solution maximizes the weighted product of the worker's and firm's

[18] This assumption affects the reservation productivity coming out of unemployment (and thus the duration of unemployment spells) but does not qualitatively alter the role of the pension contract.

net surplus from the job match over their outside options, where $\tau(Y)$ is an increasing function of the worker's bargaining weight θ. The worker receives a share of current output $\tau^{ns}(Y) < Y$ if there is no search or $\tau^{s}(Y) < Y - c(Y)$ if the worker searches OTJ. The firm receives the residual production after paying the worker's wage. This leads to an additional asymmetry – the firm bears part of the direct cost of search but enjoys none of its benefits.

3.2 The value of jobs

We will now determine the value to the worker and firm of a job with productivity Y. Since we assume that the outside options $b^w = b^f = 0$, then the worker's valuation of unemployment U and the firm's valuation of a vacancy V reflect the present expected value of a future match. Each agent's valuation of a Y-productivity match is determined as the sum of the expected discounted values of their share of production, possible future production in other matches, and their outside option. Let $W^s(Y)$ and $W^{ns}(Y)$ reflect the worker's valuations of matches that involve searching OTJ and not searching, respectively, and let $J^s(Y)$ and $J^{ns}(Y)$ reflect the firm's valuations.

Unemployment and Vacancy. We define r as the threshold productivity level below which unemployed agents' valuation of a match is exceeded by their outside option, i.e., unemployment. For a productivity draw $Y < r$, a match is not formed. We define $S > r$ as the search-deterring threshold, above which employed workers' valuation of the current match exceeds the value of searching OTJ.

A worker's value of unemployment U is constant and equal to the expected discounted future value of next period's draw,

$$U = \beta \int_0^r U dF(y) + \beta \int_r^S W^s(y) \, dF(y) + \beta \int_S^1 W^{ns}(y) \, dF(y), \tag{1}$$

where the first term represents rejected matches (with $Y < r$) and the last two terms represent the expected values of matching with productivity draws such that workers search ($r < Y < S$) or do not search ($S < Y$). The value of a vacancy for a firm V is expressed similarly:[19]

$$V = \beta \int_0^r V dF(y) + \beta \int_r^S J^s(y)\, dF(y) + \beta \int_S^1 J^{ns}(y)\, dF(y). \tag{2}$$

Employment. If $S < Y$, the worker will not search after accepting the job since the cost of search outweighs the expected gain from finding a more suitable match. This arises because the cost of search increases in Y while the likelihood of finding an acceptable alternative shrinks in Y. In the intermediate range $r < Y < S$, the worker will search after accepting the job and accepts any new offer with a draw exceeding the reservation productivity $R(Y)$, determined below. We examine each of these cases next.

For matches in which the productivity draw exceeds the search-deterring threshold ($S < Y$), the worker's value of a job is determined by her current wage $\tau^{ns}(Y)$ and the expected value of the current match next period. Since the worker is not searching, two possibilities exist: she remains employed in the current job with valuation $W^{ns}(Y)$ with probability $1-\delta$, or she experiences an exogenous layoff with probability δ and re-enters unemployment with valuation U. Thus, the worker's and firm's valuation of the job with no search is, respectively,

$$W^{ns}(Y) = \tau^{ns}(Y) + \beta\delta U + \beta(1-\delta) W^{ns}(Y). \tag{3}$$

and

$$J^{ns}(Y) = Y - \tau^{ns}(Y) + \beta\delta V + \beta(1-\delta) J^{ns}(Y). \tag{4}$$

The first term in $W^{ns}(Y)$ and the first two in $J^{ns}(Y)$ indicate the split of current output, while the remaining terms represent the expected present value of next period's possible outcomes.

On the other hand, if the productivity draw is not sufficiently high to deter search ($Y < S$), the worker's value of a job depends on her current wage $\tau^s(Y)$ which is net of the

[19] A standard assumption in general equilibrium search models is to assume that competition reduces the value of a vacancy to zero in the steady-state. While this assumption would not alter the qualitative conclusions, we leave the extension to general equilibrium to future research.

search cost $c(Y)$, the expected value of the current match next period, *and* the expected value of new productivity draws that the worker receives while searching.[20] Thus, the valuation of the job with OTJ search is

$$W^s\left(Y\right) = \tau^s\left(Y\right) + \beta\delta U + \beta\left(1-\delta\right) Z\left(Y\right), \tag{5}$$

where

$$Z\left(Y\right) = W^s(Y)F(R(Y)) + \int_{R(Y)}^{S} W^s(y)dF(y) + \int_{S}^{1} W^{ns}(y)dF(y).$$

Compared to a match with no search, the worker incurs search costs and may separate from the firm in case of a sufficiently attractive new job offer. When the worker searches, the value of the job to the firm is

$$J^s\left(Y\right) = Y - c\left(Y\right) - \tau^s\left(Y\right) + \beta\delta V + \beta\left(1-\delta\right)\left[J^s\left(Y\right)F\left(Y\right) + V\left(1-F\left(Y\right)\right)\right]. \tag{6}$$

The first term in $W^s(Y)$ and the first three in $J^s(Y)$ show the split of output net of search costs, while the remaining terms represent the expected present value of either layoff, continued production, or the worker quitting for a better job.

The nature of the asymmetries between worker and firm is now apparent. Both share the surplus of the current job, but the worker may choose to incur search costs which reduce that surplus. Also, a searching worker has access to better opportunities than the firm, which cannot post a vacancy before the quit and also faces risky future employment prospects. These factors drive a wedge between the value of the job to the worker versus the firm when the worker searches. It is because of these asymmetries that the firm might offer a pension contract. If such a contract will prevent the worker from searching by effectively lowering the search-deterring threshold, then the firm can avoid both the costs of search and the loss resulting from a quit.

[20] Under Nash bargaining, the wage function, which we derive explicitly below, will have different forms depending on whether or not the worker chooses to search.

3.3 Reservation productivity levels

Reservation productivity for the unemployed. We now consider the productivity threshold that determines matches with positive net surplus. If $r > Y$, the match will be attractive to neither the worker nor firm. Thus, r is the productivity level at which workers and firms are just indifferent between producing and returning to the matching pool. This yields the following condition:

$$W^s(r) - U + J^s(r) - V = 0,$$

in which we have explicitly assumed that some search occurs.[21] It is then straightforward, based on our Nash bargaining assumption, to derive the following condition for the employment threshold r:

$$r = \tau^s(r) + c(r) + (1 - \beta) V. \tag{7}$$

r defines the productivity at which all those matches with $r < Y$ yield strictly positive surplus.

Reservation productivities for OTJ search. We next focus on the conditions under which workers search OTJ. A worker with a job yielding Y will accept any new job with productivity draw Y' such that $W^s(Y) < W(Y')$.[22] The productivity level at which the worker is just indifferent to the new job occurs at $R(Y)$. The acceptance condition can be summarized in the following lemma (all proofs are in the appendix):

Lemma 1 ***Job-to-job acceptance threshold.*** *Given (5), a worker currently in a match with productivity $Y < S$ and therefore searching on-the-job will accept any new match with productivity $Y < Y'$. Thus, $R(Y) = Y$.*

[21] This amounts to assuming that $r < S$, so at productivity levels around r, workers choose to search since $W^{ns}(r) < W^s(r)$. This reduces the worker's decision to a choice between remaining in the unemployment pool and accepting a job in which she will search.

[22] The lack of the superscript on the right-hand side explicitly assumes the possibility of matching to a search-deterring job. In practice, since $S < Y$ implies $W^s(Y) < W^{ns}(Y)$, then any draw with $S < Y$ will dominate any job with $Y < S$. We therefore concentrate on determining an acceptance threshold against other jobs below the search-deterring threshold.

This lemma shows that a searching worker accepts any job that yields higher productivity than the current job. Not all workers, however, choose to search OTJ. Although better offers are possible, a worker with current productivity $Y > S$ does not search because the expected gain is outweighed by the search cost. Consider a worker in a match currently yielding any $Y > r$. The worker's gain from search $\Phi(Y) = W^s(Y) - W^{ns}(Y)$ is

$$\Phi(Y) = \tau^s(Y) - \frac{\tau^{ns}(Y)}{k} + (1-k)\left[\begin{array}{c} W^s(Y)F(Y) + \int_Y^S W^s(y)dF(y) \\ + \int_S^1 \frac{\tau^{ns}(y)}{k}dF(y) - \frac{\beta\delta U F(S)}{k} \end{array}\right], \tag{8}$$

where $k = 1 - \beta(1-\delta)$. From (3) and (5), it is evident that the gain from search $\Phi(Y)$ decreases in Y, since higher productivity makes the current match increasingly attractive relative to other possible matches. At the search-deterring threshold, $\Phi(S) = 0$ and the worker is indifferent between searching and receiving $W^s(S)$ or not searching and receiving $W^{ns}(S)$. We summarize this condition in the following lemma:

Lemma 2 ***Search-deterring threshold.*** *A worker is indifferent between searching and not searching at a productivity level S which solves*

$$[1-\beta(1-\delta)F(S)]\tau^{ns}(S) - [1-\beta(1-\delta)]\tau^s(S) = \beta(1-\delta)\int_S^1 \tau^{ns}(y)\,dF(y).$$

A consequence of these lemmas is that the support of the productivity distribution over which the worker engages in OTJ search is not state- or time-dependent, but rather is uniform across all worker-history combinations. Thus, the thresholds r and S are independent of the idiosyncratic match-specific productivity, work history, etc., allowing us to compute a pension contract that depends only on current productivity Y. The worker's gain from search (8) reveals the worker's incentives at varying levels of productivity and will play a key role in determining the existence of the pension contract that we outline below.

3.4 Wages

We assume that agents bargain over the match surplus to determine the worker's compensation. Since U and V are each agents' threat points, the wage is set according to the generalized Nash bargaining rule

$$W(Y) - U = \theta\left[W(Y) - U + J(Y) - V\right], \tag{9}$$

where θ represents the worker's bargaining weight and which holds with the addition of the appropriate superscripts for search and no-search.

From (3) and (4), the no-search sharing rule results in a wage function of the form

$$\tau^{ns}(Y) = \theta Y + (1-\theta)(1-\beta)U - \theta(1-\beta)V. \tag{10}$$

The no-search wage is an increasing affine function of match output Y. Part of the wage is determined as a portion of output, and the rest is related to agents' threat points, with both parts depending on the worker's bargaining weight.[23]

The worker's wage while searching can be determined similarly. From (5) and (6) above, and noting that $R(Y) = Y$, the worker's wage while searching becomes

$$\begin{aligned} \tau^{s}(Y) &= (1-\theta)U\left[\delta(1-\beta) - \beta(1-\delta)(F(Y) - F(r))\right] \\ &\quad +\theta(Y - c(Y)) + \beta(1-\theta)(1-\delta)\int_r^Y W^s(y)\,dF(y) - \theta(1-\beta)V, \end{aligned} \tag{11}$$

which can be rewritten in terms of the no-search wage (11):

$$\begin{aligned} \tau^{s}(Y) &= \tau^{ns}(Y) - \theta c(Y) \\ &\quad + (1-\theta)(1-\delta)\left[\beta\int_r^Y \left[W^s(y) - U\right]dF(y) - (1-\beta)U\right]. \end{aligned} \tag{12}$$

The deviation between the wage paid to a searching and a non-searching worker with the same productivity can be split into two components: (i) the worker's share of the search

[23] In principle, the wage function (10) is valid for all productivity levels so long as the worker chooses not to search. In practice, this wage level will only be observed for matches with productivity levels above the search-deterring threshold S.

costs and (ii) the premium on the *search asymmetry.* (i) reduces the wage that the firm must pay but not by the full cost of search, and for productivity levels sufficiently above the employment threshold r, (ii) represents an additional cost to the firm that is increasing in Y and provides more motivation for the firm to deter search.

4 The Pension Contract

As we have emphasized, a firm matched to a worker searching OTJ experiences losses from three sources: (i) search itself costs the match $c(Y)$; (ii) output is lost when the firm stands idle immediately after the worker departs; and (iii) the match with known productivity is replaced by an uncertain future draw.[24] Consequently, the firm will compensate the worker for not searching as long as the compensation does not exceed the gain to the firm from deterring search. Similarly, the worker will accept the compensation as long as it exceeds the value of opportunities lost from not searching. In this section we propose a contract which meets these conditions and takes a form similar to a tenure-based pension.

Our proposed contract defers a portion of output destined for the worker, with the payment forfeited if the worker quits. This payment is made in addition to the wage and lengthens expected tenure by deterring search. Since we do not model retirement, we make a simplifying assumption that workers receive the payment in a lump-sum when the layoff shock inevitably hits.[25] Once we eliminate the risk that the worker loses the payment because of an exogenous early exit, we can characterize the minimum deferral that provides the incentives in which we are interested.[26]

[24] Our results differ along all these dimensions from Pissarides (2000), who found that search by workers makes firms better off. First, in our model workers and firms share search costs. Second, Pissarides assumed that firms always match at the highest level of productivity, so they do not face an uncertain productivity draw. Finally, firms in Pissarides' model open vacancies until their value is equal to zero, whereas in our model a continuum of firms exist and have vacancies only when they are not producing.

[25] Figure 1 showed that DB pension accruals in the real world eventually turn negative after 20-30 years, encouraging retirement. However, FO argued that it is unlikely that an exogenous increase in optimal retirement ages caused the decline in DB pension use, so we ignore this aspect of DB pensions.

[26] FO and Stevens (2004) elaborated on the tension that arises in a risky environment between the promised pension benefit and the pension's termination date. While pension buyouts are sometimes offered, most exogenous shocks such as layoffs and health crises wipe out expected future pension accruals at risk. If we extended our model so that the pension were forfeited by any early end to the match, even involuntary, it would further narrow the productivity range defining a feasible contract (since relatively unproductive matches would not finance a large enough deferred payment to get the worker to accept the early termination risk). In Burdett and Coles (2003), risk-averse workers prefer upfront pay in order to smooth consumption,

4.1 Will the firm offer a pension contract?

A firm may offer a pension – a lump-sum payment at the end of the match that is forfeited if the worker quits – for the purpose of preventing OTJ search.[27] We assume that this alternative contract pays the same wage $\tau^s(Y)$ as in the search case but also guarantees a lump-sum payment $\Pi(Y,T)$ at the end of tenure T if the worker did not search. The magnitude of the pension $\Pi(Y,T)$ payable at T is the sum of per-period contributions $P(Y)$ invested at the risk-free rate and depends on the benefit to the firm of deterring search, the benefit of search to the worker, and the worker's tenure. The current value of the wage and the exact amount deferred are chosen to simplify computation. Any equivalent combination which satisfies the incentive conditions outlined below could be observed.[28]

Let $\Gamma(Y)$ represent the firm's valuation of deterring search. Thus, $\Gamma(Y) = J^{ns}(Y) - J^s(Y)$ and is the firm's counterpart to the worker's gain from search $\Phi(Y)$. It is straightforward to show that

$$\Gamma(Y) = c(Y) + \beta(1-\delta)\left[J^{ns}(Y) - J^s(Y)F(Y) - V\left[1-F(Y)\right]\right], \tag{13}$$

where the first term reflects the gain from avoiding search costs and the second term reflects the gain from avoiding a vacancy. Equation (13) represents one step toward demonstrating that the pension contract is feasible. It quantifies the willingness of the firm, through the pension, to voluntarily yield a portion of its share of output in order to avoid productivity losses. The following proposition lays out the next step:

Proposition 3 ***Firm's gain from deterring OTJ search.*** *For all productivity levels Y in the range $r < Y < S$, the maximum pension $P_{\max}(Y)$ the firm is willing to offer is*

which in our model would again narrow the productivity range over which pensions are feasible.

[27] Our pension is similar to the efficiency wage of Shimer (2003), which transfers a portion of output from the firm to the worker to prevent search. We ignore the possibility that the firm breaches the pension contract by withholding the promised payment. DB pensions are partially insured, and in addition, there is little empirical evidence of obvious breach by employers, as described in FO.

[28] Assuming the same wage allows us to pin down the features of the minimum pension contract. If the worker and firm had different time or risk preferences, then the split between current future payments would take on more importance. Also, if it is difficult to condition the contract on not searching, then an explicit tenure-based structure may dominate.

equal to $\Gamma(Y)$*, setting* $J^{ns}(Y) = J^{s}(Y)$*:*

$$P_{\max}(Y) = c(Y) + \beta(1-\delta)\left[\left(J^{s}(Y) - V\right)(1 - F(Y))\right] > 0.$$

The proposition demonstrates that the firm always benefits from deterring OTJ search. This occurs because the firm bears some of the costs of search but receives none of the benefits. Moreover, the maximum value of the pension payment $P_{\max}(Y)$ rises monotonically with Y, since search costs rise with Y and since higher productivity matches increase in expected value over a new match.

4.2 Will the worker accept a pension contract?

Now, we consider the worker's value of those jobs in which the worker might search and might be offered a pension contract. If a worker in a job with productivity Y had a pension contract and continued to search, the value of the job would be

$$\begin{aligned} W^{s,p}(Y) &= \tau^{s}(Y) + \beta\delta U + \beta(1-\delta) \\ &\times \left[W^{s,p}(Y)F(Y) + \int_{Y}^{S^{p}} W^{s,p}(y)dF(y) + \int_{S^{p}}^{1} W^{ns,p}(y)dF(y) \right], \end{aligned}$$

where S^{p} reflects the new search-deterring threshold conditional on having accepted the pension contract. $W^{s,p}(Y)$ factors in the expected loss of the pension payment along with the direct cost in the event of search. The worker's valuation of the same job when not searching becomes

$$W^{ns,p}(Y) = \tau^{s}(Y) + P(Y) + \beta\delta U + \beta(1-\delta) W^{ns,p}(Y), \tag{14}$$

In both cases, the wage payment under the pension contract is identical to the searching wage payment by assumption, as we noted earlier. In this latter case, the valuation is augmented by the firm's per-period contribution to the pension, $P(Y)$.[29]

[29] Once the firm promises a pension $P(Y)$ at the outset, it no longer has to set aside additional funds because the problem is stationary and the initial amount $P(Y)$ will continue to deter search. The *ex post*

Two issues arise regarding the incentives of the worker. First, the worker must choose to accept the pension contract. This condition is satisfied for some productivity levels $Y < S$ if the job with the pension contract dominates the job without the pension contract and with search:

$$W^{s}(Y) \leq W^{ns,p}(Y) \text{ or } W^{s}(Y) \leq W^{s,p}(Y).$$

Second, the value of the pension must be sufficiently high to deter search or else the firm will not offer the contract. This condition is satisfied if

$$W^{s,p}(Y) \leq W^{ns,p}(Y),$$

which subsumes the first condition and leads to the following proposition:

Proposition 4 ***Existence of the pension contract.*** *Suppose the partition of the productivity distribution's support over which workers search on-the-job is non-degenerate – that is, $r < S$. Then, there exists some Y such that $r < Y < S$ and $\Psi(Y) = \Gamma(Y) - \Phi(Y) > 0$. Moreover, $\Psi(Y) > 0$ implies that there exists some $P(Y) > 0$ that is both offered and accepted. Equivalently, there exists some Y such that $r < Y < S$ and $W^{s}(Y) \leq W^{ns,p}(Y)$. The worker accepts any pension contract that offers a current period wage $\tau^{s}(Y)$ and per-period pension contribution $P(Y)$ obeying*

$$P(Y) \geq \beta(1-\delta)\left[\begin{array}{c} W^{s,p}(Y)F(Y) + \int_{Y}^{S^p} W^{s,p}(y)dF(y) \\ + \int_{S^p}^{1} W^{ns,p}(y)dF(y) - W^{ns,p}(Y) \end{array}\right]. \tag{15}$$

This proposition shows, and Figure 4 illustrates, that over at least some portion of the relevant region $r < Y < S$ of the productivity distribution, the pension is indeed effective in deterring search. In that range, the firm's gain $\Gamma(Y)$ from deterring search exceeds the worker's gain $\Phi(Y)$ from searching, so there is a pension benefit $P(Y) > 0$ that the firm is willing to offer, that the worker accepts, and that deters the worker from searching. As

gain to the firm from deterring search will almost certainly differ from $P(Y)$, depending on when the layoff shock δ occurs. We may assume that an insurance market eliminates the risk of early or late termination.

shown in Figure 4, $\Phi(Y)$ falls with Y and defines S at the point where $\Phi(Y) = 0$, while $\Gamma(Y)$ is positive and rises with Y. The pension will consequently be effective at $Y = S - \epsilon$, where ϵ is an arbitrarily small number, since $\Phi(S) = 0$ and $0 < \Gamma(S)$. Next, we discuss the extent of the region below S over which the pension is effective.

4.3 The pension-feasible region

While we have proved that the pension contract exists, Figure 4 demonstrates that OTJ search might not be discouraged by pensions at some productivity levels. While firms want to eliminate search at all Y (since $\Gamma(Y) > 0$), for some values of Y the worker's incentives cannot be changed for less than the firm will sacrifice. If pensions are infeasible in some matches, it would occur in the lowest productivity matches with OTJ search, i.e. over some range beginning at $Y = r$. This occurs in Figure 4, since $\Phi(Y)$ and $\Gamma(Y)$ intersect at a value of $Y > r$. We denote this value as S^p, defined as the reservation productivity level which renders the pension contract infeasible for matches with $Y < S^p$.

To characterize the pension-feasible region, we consider the condition under which, given acceptance of the pension contract, the worker chooses not to search. The pension-feasible region is largest when the firm offers the maximum pension, corresponding to $P(Y) = \Gamma(Y)$, which it is willing to do as long as it deters search. Thus, the pension-feasible region extends from S^p up to S, where S^p is determined by

$$c(S^p) = \beta(1-\delta) \int_{S^p}^{1} \left[W^{ns,p}(y) - W^{ns,p}(S^p) - J^s(S^p) + V\right] dF(y). \tag{16}$$

At S^p, the cost of searching is exactly the expected discounted value of a new match, accounting for the foregone value of the pension.[30] If the maximum per-period pension contribution $\Gamma(Y)$ is smaller than the minimum pension required by the worker, as defined by condition (15), then any pension the firm is willing to offer will not be incentive-compatible, since it fails to discourage search.

While (13) reveals the firm's willingness to sacrifice some of its surplus to deter the

[30] We cannot further pin down $S^p \in (r, S]$ without assuming a particular distribution of productivity and making additional simplifications.

worker from searching, the firm need offer no more than the minimum pension that satisfies (15). A pension is effective, therefore, if total expected losses from search exceed expected gains – leading both agents to fully internalize the costs and benefits of search that accrue in the match. While pension contracts enhance the value of the current job, they may, however, raise or lower aggregate welfare, since new matches that dominate current ones are not formed.[31]

To sum up, pension contracts exist in medium-productivity jobs (matches with $r \leq S^p < Y < S$) and not in the highest-productivity search-deterring jobs (with $S < Y$). Moreover, it is likely that the threshold S^p is relevant, since we observe that DB pensions are least common in low-wage jobs.[32]

5 Extensions of the baseline model

The feasibility and size of the pension contract shift if the value of the match to the worker or firm changes. This will in turn alter the degree to which workers search OTJ. In this section, we analyze how either a decline in search costs or a rise in the matching rate, which we earlier assumed to be 1, changes the value of the current job relative to alternatives. This discussion ties into important trends that we discussed earlier – notably, the increased incidence of job-to-job flows and the increase in relative wages associated with such flows, as well as indirect evidence of declining search costs and frequent OTJ search. We consider the impact of both changes in search costs and in the match probability since we have little concrete evidence about long-term trends in either and since they have similar implications for the feasibility of the pension contract.[33]

[31] In a very different model, Nagypál (2002) investigated the aggregate welfare consequences of employment protection policies that raise the cost of dismissal when there is learning in matches. She studied inefficiencies generated by the use of legal employment protection to prevent layoffs, while we study pensions that prevent quits.

[32] In the real world, many very high-wage workers have pensions. A reasonable explanation is that high-wage workers have high marginal tax rates, and pensions are lightly taxed relative to wages; this motivation is not contract-theoretic and lies beyond the scope of this paper.

[33] Other possible extensions of the baseline model include adding outside options b (e.g., unemployment insurance), skewness in the distribution of potential matches, and asymmetric information about (current or future) match productivty. Each of these alternations may influence the size of the pension-feasible region and the magnitude of the minimum pension offered without undermining their basic function.

5.1 Decline in search costs

We first consider the effect of a simple reduction in search costs. Suppose that search costs uniformly decrease from $c_0(Y)$ to $c_1(Y) \leq c_0(Y)\ \forall Y$. This alters the worker's gains from search $\Phi(Y)$ and the firm's maximum pension offer $\Gamma(Y)$, and in turn the value of the pension $P(Y)$. We are most interested in whether this changes the threshold of productivity S^p below which the pension is rendered incentive-incompatible. The following proposition summarizes the consequences for the match:

Proposition 5 ***Decrease in Search Costs****.* *A decrease in search costs causes (i) a* decrease *in the firm's gains from preventing search* $\Gamma(Y)$*, (ii) an* increase *in the worker's gains from search* $\Phi(Y)$*, (iii) an* increase *in the search-deterring threshold* S*, and (iv) an* increase *in* S^p*.*

These effects are illustrated in Figure 5 and arise both because $\tau_1^s(Y) > \tau_0^s(Y)$, where the subscripts refer to the change in search costs from $c_0(Y)$ to $c_1(Y) \leq c_0(Y)$, and because $Y - c_1(Y) > Y - c_0(Y)$.[34] Through both effects, the worker gets to keep more of current output in the event of search, boosting the gains from search, defined in (8), from $\Phi_1(Y)$ to $\Phi_2(Y)$. That in turn raises the search threshold from S_0 computed from search costs $c_0(Y)$ to $S_1 > S_0$. Therefore, in the absence of pension contracts, some workers previously satisfied with Y will begin to search.

These changes will clearly influence the viability and size of the pension contract. The increase in the worker's $\Phi(Y)$ makes it more costly for firms to discourage search. Also, because the firm gets to keep more of current output in the event of search, it reduces the gain from preventing search from $\Gamma_1(Y)$ to $\Gamma_2(Y)$ and hence the maximum pension $P(Y) = \Gamma(Y)$ the firm is willing to offer, as defined in (13).

We argue that under realistic parameters, the pension-feasible region will probably shrink, and hence the total number of pensions offered in the economy will decrease while the number of workers who search will increase – as has probably occurred in recent years.[35]

[34] Note that there may be enough workers with $S_0 < Y < S_1$ such that total output net of search costs decreases rather than increases.

[35] The economy will immediately enter a new steady state like this one if existing pensions contracts are renegotiated. If not, then all existing pensions will be too small to deter search and will be abandoned, and

The ambiguity arises because of two countervailing effects. The pension-feasible region may get squeezed at the lower end while it expands at the upper end, so the actual outcome depends on the density of the productivity distribution in different regions. On the one hand, if it was already the case that $r < S^p$ as in Figure 5, so that the pension contract failed to deter some workers in relatively less productive matches from searching OTJ, then S^p will increase, so pensions in some additional matches are no longer feasible. We already argued that this is likely to be the case, as low wage jobs are much less likely to offer pensions. If the density of matches is high in the productivity range over which S^p rises, then even a small decrease in search costs could cause a large decrease in the use of pension contracts and an associated increase in search.

On the other hand, the pension-feasible region gets expanded from above, as the search-deterring threshold S rises. In matches in which search is now attractive but was not before, $\Phi(Y)$ is small relative to $\Gamma(Y)$, so firms will begin to offer pensions. However, unless the productivity distribution is skewed strongly to the right and therefore the mass of matches without search is large (which seems unlikely, or else OTJ search and job-to-job flows would be very uncommon), then the first effect (the squeeze from below) will dominate the second (the expansion from above), and the number of pensions will decline.[36]

We can also draw a parallel between the shift in the range over which OTJ search is considered and relative wage changes associated with job-to-job flows. As we mentioned earlier, we found that, as job-to-job flows have become more common, the relative wages of recent job-to-job movers have also improved. This occurs in our model as a consequence of lower search costs, which raise the average productivity of jobs in which pensions fail to deter search. Moreover, the effects of a decline in the cost of search are robust to other specifications of search costs. If search costs are borne entirely by the worker, then a decline induces more search because $\Phi(Y)$ rises and the incentive-compatibility constraint binds for more matches, with no increased funding for pensions to counteract the effect. If search

the economy will reach the new steady state after workers reshuffle into new jobs with new pensions.

[36] The average value of remaining pensions may also change, depending on the density of Y and on other parameters. At the lower end, the largest pensions will disappear but remaining pensions will get bigger; while at the upper end, the new pensions that appear will be small. Evidence in FO suggests that remaining DB pensions are becoming less valuable on average.

costs are borne entirely by the firm, then a decline induces more search because $\Gamma(Y)$ falls as search becomes less costly for the firm, so fewer pensions will be offered. The same effects occur whether search costs are a function of productivity Y or are constant. To sum up, our model implies that the number of pensions is likely to fall when the costs of OTJ search decline.

5.2 Uncertain matching

In this subsection, we incorporate a match probability of $\lambda \leq 1$, which is a common feature of matching models and prolongs search. As we noted earlier, we have little evidence about the nature of λ, but we show that an increase in λ has the same types of effects as a decline in search costs. A match probability of $\lambda < 1$ will generate a wedge between current productivity and the acceptance threshold, extend the duration of unemployment, and alter the pension-feasible region. Because the expected duration of search increases, both the worker's value of unemployment,

$$U = \beta \begin{bmatrix} (1-\lambda) U + \lambda \int_0^r U dF(y) \\ +\lambda \int_r^S W^s(y) dF(y) + \lambda \int_S^1 W^{ns}(y) dF(y) \end{bmatrix}, \tag{17}$$

and the firm's value of a vacancy,

$$V = \beta \begin{bmatrix} (1-\lambda) V + \lambda \int_0^r V dF(y) \\ +\lambda \int_r^S J^s(y) dF(y) + \lambda \int_S^1 J^{ns}(y) dF(y) \end{bmatrix}, \tag{18}$$

decline. Here, the first term in each equation is new and shows that agents might not meet during the current period.

While a match rate $\lambda < 1$ alters the worker's search-deterring threshold S, the valuations of employment by workers and firms, (3) and (4), take the same form, while the actual values are altered by the declines in U and V. Similarly, the form of the wage for workers who do not search remains (10). Conditional on searching, the worker's valuation of the match now becomes

$$W^{s}(Y)=\frac{1}{\Lambda(Y)}\left[\begin{array}{c}\tau^{s}(Y)+\beta\delta U+\beta\lambda(1-\delta)\\ \times\left[\int_{Y}^{S}W^{s}(y)dF(y)+\int_{S}^{1}W^{ns}(y)dF(y)\right]\end{array}\right], \tag{19}$$

where $\Lambda(Y)=1-\beta(1-\delta)[1-\lambda(1-F(Y))]$. The value of the match to the firm when the worker searches is defined similarly:

$$J^{s}(Y)=\frac{1}{\Lambda(Y)}\left[Y-c(Y)-\tau^{s}(Y)+\beta\delta V+\beta\lambda(1-\delta)[1-F(Y)]\right]V. \tag{20}$$

As before, a worker searches OTJ if her productivity level Y is below the threshold S, determined by

$$\Lambda(S)\tau^{ns}(S)-[1-\beta(1-\delta)]\tau^{s}(S)=\beta\lambda(1-\delta)\int_{S}^{1}\tau^{ns}(y)\,dF(y), \tag{21}$$

and from (19) and (20) above, the worker's wage while searching becomes

$$\begin{aligned}\tau^{s}(Y) &= \theta[Y-c(Y)]+(1-\beta)[(1-\theta)\delta U-\theta V]\\ &\quad+\beta\lambda(1-\theta)(1-\delta)\int_{r}^{Y}[W^{s}(y)-U]\,dF(y).\end{aligned}$$

We are particularly interested in how a shift in λ affects both the region in which OTJ search occurs and the region in which the pension is feasible. An increase in λ decreases the expected duration of search – thereby causing a decrease in its expected cost – and thus raises the value of searching OTJ. As is the case with a decline in search costs, this change will alter the bounds determining the pension-feasible region. The pension-feasible region is characterized, as above, by the upper-bound S, above which workers have no incentive to search even without a pension, and a lower-bound S^{p}, below which the firm cannot compensate the worker enough not to search even with a pension. With uncertain matching, this lower boundary is determined by

$$c\left(S^{p}\right)=(1-k)\left[\begin{array}{c}(1-\lambda)\left(U-W^{ns,p}(S^{p})\right)\\+\lambda\int_{S^{p}}^{1}\left[W^{ns,p}(y)-W^{ns,p}(S^{p})-J^{s}+V\right]dF(y)\end{array}\right], \tag{22}$$

where again $k=1-\beta(1-\delta)$.

Proposition 6 ***Increase in Match Probability***. *Suppose that* $\lambda<1$. *An increase in the match probability* λ *causes (i) a* decrease *in the firm's gains from preventing search* $\Gamma(Y)$, *(ii) an* increase *in the worker's gains from search* $\Phi(Y)$, *(iii) an* increase *in the search-deterring threshold* S, *and (iv) an* increase *in* S^{p}.

The proposition shows that, in a model in which matching is uncertain, an increase in the matching rate λ is isomorphic to a decline in search costs. In both cases, search becomes more appealing to the worker. Devoid of pensions, more workers would search since the likelihood of finding new matches increases. This increase in the gains from search is reflected in a higher value of the search-deterring threshold . Firms are affected through their ability to deter search with pensions. Workers with sufficiently low productivities (i.e., productivities just above the old S^{p}) can no longer be persuaded by the pension contract to forgo search. This could lead to a collapse of the pension-feasible region, depending on the underlying productivity distribution.

6 Conclusions

In the midst of the economic boom of the 1990s, the New York Times suggested that "the notion of lifetime employment has come to seem as dated as soda jerks, or tail fins" (Kolbert and Clymer, 1996).[37] While media reports have highlighted a decline in job stability for some time, economists have only recently found evidence that job tenure has declined. Other new evidence shows that job-to-job flows have increased in frequency over a similar period.

In this paper we propose a model of on-the-job search and job-to-job flows to help explain these changes. Recent data makes it clear that these activities are common, yet they are

[37] We have appropriated this quote, with thanks, from Neumark, Polsky, and Hansen (1999).

actively discouraged by DB pensions. The decline in the use of DB pensions suggests an important link with trends in tenure and job-to-job flows. Other recent theoretical papers have also tied together the motive to search on-the-job with the use of tenure-based deferred compensation contracts. We propose a model with some distinct features that add to our understanding of the costs and benefits of on-the-job search and, consequently, the feasibility of tenure-based contracts. We then highlight changes in the expected value of search that can explain the declining use of such contracts. We focus on a decline in search costs which, under fairly general conditions, would reduce the use of DB pensions and boost worker mobility. A jump in the expected gains from search tallies with observed growth in relative wages of job-to-job movers.

Further research on the causes and consequences of the recent decline in job tenure and the connection to job-to-job flows will be important. Identifying the causes will ultimately allow a careful evaluation of the welfare consequences for workers and firms. For example, such an analysis might determine whether DB pensions have become socially inefficient, even if they remain privately efficient. In our model, pensions internalize the costs and benefits of search within the match but impede matches that offer higher surplus to a new firm from being formed. It is relevant that some of the federal pension regulations implemented since 1974 constrain the degree to which DB pensions can be designed to condition compensation on tenure (Clark and McDermed, 1990). This raises the possibility that regulations were implemented in response to rising social gains from mobility resulting from the types of changes we have outlined here. Our paper represents a step towards understanding the causes and consequences of increased mobility.

7 Appendix: Proofs

Proof of Lemma 1:

The worker's current continuation value is

$$\begin{aligned} W^s(Y) &= \tau^s(Y) + \beta\delta U + \beta(1-\delta) \\ &\times \left[W^s(Y)F(R(Y)) + \int_{R(Y)}^{S} W^s(y)dF(y) + \int_S^1 W^{ns}(y)dF(y) \right] \end{aligned}$$

and the value of the new match is

$$\begin{aligned} W^s(Y') &= \tau^s(Y') + \beta\delta U + \beta(1-\delta) \\ &\times \left[W^s(Y')F(R(Y')) + \int_{R(Y')}^{S} W^s(y)dF(y) + \int_S^1 W^{ns}(y)dF(y) \right] \end{aligned}$$

The acceptance threshold is defined as the minimum Y' that satisfies $W^s(Y') > W^s(Y)$. By construction, $W^s(Y)$ is monotonically increasing in Y, which yields the result.[38]□

Proof of Lemma 2:

By definition, at $Y = S$, the worker is indifferent between searching and not searching. Thus,

$$W^{ns}(S) = W^s(S).$$

Combining this with (**??**) gives

$$\begin{aligned} \frac{\tau^{ns}(S) + \beta\delta U}{1-\beta(1-\delta)} &= \tau^s(S) + \beta\delta U \\ &+ \frac{\beta(1-\delta)}{1-\beta(1-\delta)} \begin{bmatrix} \tau^{ns}(S) + \beta\delta U F(S) \\ + \int_S^1 (\tau^{ns}(y) + \beta\delta U)\, dF(y) \end{bmatrix}. \end{aligned}$$

[38] Monotonicity also implies that the worker accepts $Y' > S > Y$.

Simplifying algebra yields

$$[1-\beta(1-\delta)F(S)]\,\tau^{ns}(S)-[1-\beta(1-\delta)]\,\tau^{s}(S)=\beta(1-\delta)\int_{S}^{1}\tau^{ns}(y)\,dF(y),$$

the desired result.□

Proof of Proposition 3:

The maximum pension a firm is willing to offer is the amount that renders $J^{ns,p}(Y)-J^{s}(Y)=0$. Solving for P yields the result.[39]□

Proof of Proposition 4:

The amount required to dissuade the worker from searching, $P(Y)$, solves $W^{s,p}(Y)=W^{ns,p}(Y)$:

$$P(Y)=\beta(1-\delta)\left[\begin{array}{c} W^{s,p}(Y)F(Y)+\int_{Y}^{S^p}W^{s,p}(y)dF(y)\\ +\int_{S^p}^{1}W^{ns,p}(y)dF(y)-W^{ns,p}(Y)\end{array}\right].$$

The goal is to show that there exists Y, such that $P_{\max}(Y)>P(Y)$. Recall,

$$P_{\max}(Y)=c(Y)+\beta(1-\delta)\left[\left(J^{s,p}(Y)-V\right)(1-F(Y))\right].$$

Thus, we need to find Y such that $S>Y\geq S^p$ and

$$\frac{c(Y)}{\beta(1-\delta)}+\left[\left(J^{s,p}(Y)-V\right)(1-F(Y))\right]\geq\left[\begin{array}{c} W^{s,p}(Y)F(Y)+\int_{Y}^{S^p}W^{s,p}(y)dF(y)\\ +\int_{S^p}^{1}W^{ns,p}(y)dF(y)-W^{ns,p}(Y)\end{array}\right],$$

which reduces to

$$\begin{aligned}\left(J^{s,p}(Y)-V\right)(1-F(Y)) \quad\geq\quad & W^{s,p}(Y)F(Y)+\int_{Y}^{S^p}W^{s,p}(y)dF(y)\\ & +\int_{S^p}^{1}W^{ns,p}(y)dF(y)-W^{ns,p}(Y),\end{aligned}$$

since $c(Y)\geq 0$, by definition. Further, since $S>Y\geq S^p$, $W^{ns,p}(Y)>W^{s,p}(Y)$, by

[39] Note that $P_{\max}$ is equal to setting $\Gamma(Y)=0$, since this implies that $J^{ns}(Y)=J^{s}(Y)$.

definition. Simplifying algebra yields

$$\int_{Y}^{1}\left[J^{s,p}\left(Y\right)-V+W^{ns,p}(Y)-W^{ns,p}(y)\right]dF(y)\geq 0,$$

where continuity and fact that $J^{s,p}\left(Y\right)$ and $W^{ns,p}(Y)$ are increasing in Y while $\int_{y}^{1}W^{ns,p}(y)dF(y)$ is decreasing in Y give the result.□

Proof of Proposition 5:

Consider $c_0(Y)$ and $c_1(Y)$, where $c_1(Y)<c_0(Y)$ for all $Y\geq 0$.

(i) $\Gamma_1(Y)<\Gamma_0(Y)$: From (13),

$$\begin{aligned}\Delta\Gamma(Y) &= \Delta c+\beta\left(1-\delta\right)\left[\frac{\Delta J^{ns}\left(Y\right)}{\Delta c}-F\left(Y\right)\frac{\Delta J^{s}\left(Y\right)}{\Delta c}-\left[1-F\left(Y\right)\right]\frac{\Delta V}{\Delta c}\right] \\ &= \Delta c+\beta\left(1-\delta\right)\left[\begin{array}{c}\frac{\Delta J^{ns}(Y)}{\Delta S}\frac{\Delta S}{\Delta c}-F\left(Y\right)\frac{\Delta J^{s}(Y)}{\Delta c} \\ -F\left(Y\right)\frac{\Delta J^{s}(Y)}{\Delta S}\frac{\Delta S}{\Delta c}-\left[1-F\left(Y\right)\right]\frac{\Delta V}{\Delta S}\frac{\Delta S}{\Delta c}\end{array}\right],\end{aligned}$$

where $\Delta c<0$ and $F\left(Y\right)\frac{\Delta J^{s}(Y)}{\Delta c}>0$ for all Y. If each of the second-order terms in brackets are assumed negligible, the desired result is obtained.

(ii) $\Phi_1(Y)>\Phi_0(Y)$: From (8),

$$\Delta W^{s}\left(Y\right)\approx\frac{1}{1-\beta\left(1-\delta\right)F(Y)}\left[\Delta\tau^{s}\left(Y\right)+\beta\left(1-\delta\right)\int_{Y}^{S}W^{s\prime}(y)dF(y)\right],$$

where we have, again, assumed second-order terms are negligible. Since $\Delta\tau^{s}\left(Y\right)<0$ and $W^{s\prime}(y)\geq 0$ by definition, $\int_{Y}^{S}W^{s\prime}(y)dF(y)\geq 0$ and the result is obtained.

(iii) $S_1>S_0$: Recall that S_i solves $\Phi_i(S_i)=0$. Since $\Phi_i'(Y)$ is negative at $Y=S_i$, if $\Phi_0(Y)<\Phi_1(Y)$, the result follows.

(iv) $S_1^p>S_0^p$: Recall that S_i^p solves $\Gamma_i\left(S_i\right)-\Phi_i\left(S_i\right)=0$. The result follows from (ii) and (iii) combined with single-crossing and monotonicity.□

Proof of Proposition 6:

The proof of this proposition is similar to Proposition 5.

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