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Abstract: Using Displaced Worker Survey data, this paper examines changes in the age distribution of displaced workers during the 1983–87 and 1993–97 periods. Older workers comprised a significantly larger fraction of displaced workers during the later period. Potential explanations for this phenomenon include demographic shifts in the labor force, changes in technology, and industry and occupational shifts. Kernel density estimates indicate that the aging of the labor force accounts for the majority of the shift in the age distribution of displaced workers. Changes in technology also appear to have contributed to the shift in the age distribution of displaced workers by increasing the likelihood of displacement among older workers relative to younger workers. Differential changes across age groups between goods-producing and service-producing jobs and between blue-collar and white-collar jobs appear to have had little effect on the change in the age distribution of displaced workers.

JEL classification: J21, J23

Key words: displacement, age

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Explaining Changes in the Age Distribution of Displaced Workers

In recent years, the media has devoted considerable attention to the effects of downsizing and corporate restructuring on workers, focusing particular attention on the plight of middle-aged workers. For example, a cover story in *Fortune* noted that employers appear to be laying off older workers who were previously protected by their seniority and asked whether workers are now "finished at forty" (Munk 1999). Similarly, the media characterized the downturn in the early 1990s as much tougher than previous recessions on older workers (Labich 1993). Such anecdotal evidence suggests that the age distribution of displacement may have shifted over time in a direction that disproportionately impacts older workers.

A shift in the age distribution of displaced workers would have several economic implications. Older displaced workers tend to experience longer spells of nonemployment after displacement and larger earnings losses, conditional on finding another job, than do younger workers (Valletta 1991). An increase in the number of displaced workers who are older could therefore lead to lower national income and higher costs to unemployment insurance programs. If displacement causes some older workers to permanently exit the labor force and begin drawing Social Security earlier than they would have absent displacement, then a shift in the age distribution of displaced workers would affect the finances of the Social Security program.

Previous research indicates that older workers are generally less likely to be displaced than younger workers. Data from 1968 to 1992 indicates that the likelihood of involuntary job loss is lower among older men than among younger men with the same educational attainment (Boisjoly, Duncan and Smeeding 1998). The probability of displacement also declines monotonically with age when data on both sexes are used (Farber 1993; Farber 1997).

The evidence on whether the probability of job loss has worsened over time for older workers is mixed. Farber (1993) found that the probability of job loss for workers aged 40-60 was higher in 1990-91 than in 1982-83, relative to otherwise equivalent workers aged 20-24. Polsky (1999) found that the probability of job separation, which encompasses quits and firings as well as involuntary job loss, did not increase significantly between 1976-81 and 1986-91 for male household heads aged 35-54 relative to men aged 25-34. Polsky also reported a sizable, but statistically insignificant, increase in the probability of job loss, conditional on job separation, for men aged 45-54 relative to men aged 25-34 but did not examine whether the unconditional relative probability of job loss rose for older workers. Gottschalk and Moffitt (1999) found that the proportion of exits that were involuntary increased significantly over the 1980s and 1990s for older workers but that the probability of involuntary termination did not rise over time.

In this study, we examine whether the age distribution of displaced workers has changed over the last two decades. Data from the Displaced Worker Surveys on individuals aged 25-54 indicate that older workers constitute a significantly larger fraction of displaced workers in 1993-97 than in 1983-87. This shift may reflect two phenomena. First, the fraction of displaced workers who are older may have risen over time because of the aging of the labor force, while the likelihood of displacement may have not increased for older workers. Second, the likelihood of displacement may have risen for older workers. We investigate both possibilities.

Although some previous studies have noted that displacement appears to have increasingly affected older workers, the potential causes of this shift have not been investigated. This study extends the current literature in several directions. First, we use kernel density estimates to confirm that there has indeed been a shift in the age distribution of displaced workers and to quantify the magnitude of the shift. Second, we decompose the shift in the age

distribution into several components, focusing on changes in the age distribution of the labor force, increased use of computers, and industry and occupational shifts.

The results indicate that about two-thirds of the change in the age distribution of displaced workers is due to the aging of the labor force. The results also suggest that the probability of displacement has increased over time for older workers relative to younger workers. The increased use of computers in the workplace and changes in the relationship between computer usage, displacement and age appear to have contributed to the increase in the relative probability of displacement for older workers. Industry and occupational shifts appear to have played a minor role in the change in the age distribution of displaced workers.

Theoretical Framework

The age distribution of displaced workers reflects both the age distribution of workers and the probability of displacement for workers at each age. The fraction of displaced workers who are above age 45, for example, depends on the ratio of workers above age 45 to all workers and on the probability of displacement for workers above age 45 relative to the probability of displacement for all workers. Changes in the age distribution of displaced workers can reflect either changes in the age distribution of workers or changes in the relative probabilities of displacement for workers of different ages.

Shifts in the age distribution of the labor force are likely to have contributed to changes in the age distribution of displaced workers. The baby boom, which occurred from 1946 to 1964, led to an unprecedented change in the age distribution of the labor force (Welch 1979). During the periods we examine, 1983-87 and 1993-97, the balance of the baby boomers moved from their 20s and 30s into their 30s and 40s, causing an upward shift in the age distribution of the

labor force.[1] Even if displacement rates had remained constant across age groups, shifts in the age distribution of the labor force would have led to shifts in the age distribution of displaced workers.

The age distribution of displaced workers also reflects differences in displacement rates across age groups. Displacement rates vary across age groups in part because of differences in specific human capital. Firms and workers typically share the cost and return on investment in firm- or job-specific human capital. The cost of this investment is usually incurred early during a worker's tenure and the returns obtained later, resulting in upward-sloping wage-tenure profiles (Becker 1964). A firm cannot recoup its investment in a worker's specific human capital if that worker is laid off, so firms are less likely to lay off workers who have more specific human capital than workers who have less specific human capital (Topel 1991). Since older workers tend to have more specific human capital than younger workers, employers are less likely to lay off older workers than younger workers. This negative relationship between the likelihood of displacement and age has been widely observed (Boisjoly, Duncan and Smeeding 1998; Fairlie and Kletzer 1998; Farber 1997).

Technological change may have led to changes in the returns to human capital and in age-displacement relationship. Increased use of computers and other forms of technology may have rendered previously acquired specific human capital obsolete. As computer use has increased, the specific human capital that has traditionally shielded older, more experienced workers from displacement may have become less valuable to employers. In addition, technological change may have created the need to retrain employees in new technologies. Older workers may be more expensive to retrain than younger workers because firms have a

[1] Data from the CPS outgoing rotation groups indicate that the mean age of the labor force (aged 16 and higher) rose from 36.9 during 1983-87 to 38.3 during 1993-97.

longer time to recoup the costs of retraining younger workers than older workers, possibly causing the relative likelihood of displacement to increase for older workers (Aaronson and Housinger 1999).

The evidence on displacement, technology and age is mixed. Aaronson and Housinger (1999) found a positive relationship between the probability of displacement and some measures of technology, such as computer investment and output per hour, and a negative relationship for other measures of technology, such as computer usage and total factor productivity. Addison, Fox and Ruhm (1996) reported a positive relationship between displacement and computer investment as a fraction of new investment in the manufacturing industry. Aaronson and Housinger (1999) found little support for the hypothesis that the technology-displacement relationship disproportionately affects older workers; their results suggest that the relationship between technology and the probability of displacement is weaker among older workers than among younger workers.

Differences in the industry and occupational distribution of workers in different age groups may also underlie changes in the age distribution of displaced workers. Although displacement rates appear to have increased over time for white-collar, service-producing workers, displacement still disproportionately affects blue-collar, goods-producing workers (Kletzer 1998). If older workers have become increasingly concentrated in industries and occupations with higher displacement rates, relative to younger workers, the likelihood of displacement may have risen over time for older workers relative to younger workers.

We use data from the Displaced Worker Surveys to measure the extent of the shift in the age distribution of displaced workers and to examine the contribution of demographic changes,

technological changes, and industry and occupation shifts to the change in the age distribution of displaced workers.

Data

The Displaced Worker Survey (DWS) supplements to the Current Population Survey (CPS) are the largest nationally representative source of data on displaced workers in the U.S. The survey, which has been conducted every other year since 1984, asks individuals whether they lost a job because their plant or employer shut down or moved, their job was abolished, slack work, a seasonal job ended, self employment failed or other similar reasons. In this study, we focus on only the first three reasons for displacement (plant closure, job abolished and slack work) because these reasons correspond most closely to involuntary job loss.[2]

This analysis uses data from the 1986, 1988, 1996 and 1998 DWSs and examines whether individuals report being displaced during the three years prior to the survey. During this period, the displacement interval covered by the surveys changed. Through 1992, the DWS asked whether individuals were displaced during the previous five years, while the more recent DWSs asked about displacement during the previous three years. In the earlier DWSs, workers who were displaced during the first or second year of the five-year displacement window and then were displaced again during the next three years were supposed to report the first displacement if they had longer tenure on the first lost job than on the subsequent lost job. Such workers would not be counted as displaced during the previous three years. In the 1994-98

[2] Other studies on displacement have also focused on workers displaced for these three reasons, e.g., Addison, Fox and Ruhm (1996), Fairlie and Kletzer (1998) and Podgursky and Swaim (1987). Abraham (1997) notes that only 24 to 31 percent of workers who said in the 1996 DWS that they were displaced for "other" reasons should be categorized as displaced, based on follow-up interviews.

DWSs, such workers would always report the second lost job and be counted as displaced during the previous three years.

We correct for the change in the DWS displacement interval using the method developed by Farber (1997). Using data from the PSID, Farber calculated that workers displaced in a given year have a 0.3017 percent probability, on average, of being displaced again over the next three years. For workers displaced a year ago, the average probability of being displaced again during the next three years is 0.2705. We reweight workers displaced four and five years ago in the 1986 and 1988 surveys using these probabilities. Individuals who report being displaced four or five years ago in the 1986 and 1988 DWSs are included in the sample as displaced workers, with their CPS final weights multiplied by the probability of being displaced in the three years prior to the survey. These individuals were also included as non-displaced workers, with their weights multiplied by one minus the probability of being displaced in the three years prior to the survey.

The sample used here from the four DWSs includes individuals aged 25-54 at the time of the survey who report being displaced and non-displaced individuals who are employed at the time of the survey. Individuals who are not employed at the time of the survey and do not report being displaced are not included in the sample.[3] Individuals below age 25 and above age 54 are not included because school enrollment and retirement patterns may have changed during the sample period. The sample includes both men and women. We combine the 1986 and 1988 DWSs, which together include displacements during 1983-87, and the 1996 and 1998 DWSs,

[3] We want to measure the likelihood of displacement given employment during the displacement interval. As in previous studies, we use workers employed at the survey date (and displaced workers) as the relevant pool of workers during the displacement window.

which cover displacements from 1993-97. Other DWSs are not included in order to limit the effect of examining different phases of the business cycle.[4]

Although the displacement window in the DWS has changed over time, DWS data have several advantages over data from the Panel Survey of Income Dynamics (PSID), the other main survey used to study displacement. The tenure questions in the PSID have changed over time and contain substantial measurement error, making it difficult to determine whether a worker has been displaced (Brown and Light 1992).[5] In addition, workers who are laid off or fired are classified together in the PSID, and there is a separate classification for workers who lost a job because of plant closure or other similar reasons. The laid off or fired category mixes workers who would properly be considered involuntarily displaced (laid off) with workers who are generally not regarded as involuntary job losers (fired). The PSID also includes employment histories only for household heads (and "wives" since 1979).[6]

Descriptive Statistics

Table 1 reports descriptive statistics for the sample. Combining the 1986 and 1988 DWSs, which cover displacement during the period 1983-87, about 7.6 percent of workers were displaced because of plant closure, job abolished or slack work during the three years prior to those surveys. Combining the 1996 and 1998 DWSs, which cover displacement between 1993

[4] The results are robust to including the DWSs from 1984, 1990 and 1992 and comparing the 1981-89 period to the 1990-97 period.

[5] Studies of job separations using the PSID used the reported time in current position (or with current employer) and reason for new position to determine whether workers experienced a job separation (Boisjoly, Duncan and Smeeding 1998; Gottschalk and Moffitt 1999; Polsky 1999).

[6] The PSID also has several advantages over the DWS. The PSID has a shorter recall period than the DWS, which is known to have problems with underreporting of displacement events that occurred during the early part of the displacement window (Fairlie and Kletzer 1996). The panel nature of the PSID allows for an examination of the relationship between characteristics at the beginning of an interval and subsequent displacement experience, whereas the DWS reports characteristics at the time of the survey and retrospective displacement experience. However, attrition from the PSID may limit the advantages of the survey's longer panel.

and 1997, the three-year displacement rate is about 7.4 percent. These three-year displacement rates are the ratio of workers displaced during the three years prior to the survey to non-displaced currently employed individuals plus displaced workers, not the fraction of individuals employed during those periods who were displaced.

The average age of displaced workers has clearly increased over time. As Table 1 indicates, almost one-half of workers displaced during 1983-87 are aged 25-34, compared to 38 percent of workers displaced during 1993-97. The percentage of displaced workers who are aged 35-44 rose by 5 percentage points, and the percentage who are aged 45-54 rose by more than 6 percentage points. The age distribution of non-displaced workers has also shifted toward older workers over time, although the change in the distribution across 10-year age groups of non-displaced workers is not as pronounced as the change among displaced workers.

The change in the age distribution of displaced workers may simply reflect the aging of the labor force, while the incidence of displacement among older workers may not have risen over time. However, displacement rates appear to have risen slightly among older workers. Table 2 reports the fraction of workers who report being displaced in the three previous years by 10-year age groups and by other characteristics. The displacement rate of workers aged 35-54 was slightly higher in 1993-97 than in 1983-87, while the opposite holds for workers aged 25-34. Relative to the change in displacement rates among workers aged 25-34, the displacement rate of workers aged 45-54 was 0.9 percentage points higher in 1993-97 than in 1983-87, and 0.7 percentage points higher for workers age 35-44. However, displacement rates continued to be lower among older workers than among younger workers.

The increase in displacement rates for workers aged 35-54 relative to workers aged 25-34 may be due to changes in the characteristics of workers within age groups. For example, it is

well known that displacement rates decline with educational attainment (Farber 1997). If younger workers have more education in 1993-97 than in 1983-87, the change in relative displacement rates suggested by the descriptive statistics might be due to changes in educational attainment within age groups, not due to changes in the relative probability of displacement by age. We therefore estimated probit regressions of the probability of displacement, controlling for observable characteristics that may affect the likelihood of displacement. Observations from the four DWSs were pooled, and separate coefficients were estimated for workers from the 1986/1988 DWSs and for workers from the 1996/1998 DWSs. The dependent variable is equal to one if an individual reported being displaced because of plant closure, job abolished or slack work, and zero otherwise.[7]

The probit regression results indicate that older workers are less likely to be displaced than are younger workers. Table 3 reports the estimated marginal probabilities, evaluated at the sample means. During 1983-87, workers aged 35-44 were 1.3 percent less likely to be displaced than were workers aged 25-34; workers aged 45-54 were 2.4 percent less likely to be displaced than were workers aged 25-34. The relative probability of displacement also falls with age during 1993-97. These results are similar to those reported by Farber (1997).

The relative probability of displacement was slightly higher for older workers in 1993-97 than in 1983-87. Not controlling for industry and occupation, the probability of displacement was 0.5 percent higher for workers aged 35-44 in 1993-97 than in 1983-87, relative to workers aged 25-34, but is not significant at conventional levels. For workers aged 45-54, the relative probability of displacement was 1.1 percent higher in 1993-97 than in 1983-87, and the increase

[7] In addition to the variables reported in Table 1, the regressions include two sets of indicator variables for 3 of 4 regions (one set for each time period) and an indicator variable for the period 1993-97. The reference categories in Table 3 are age 25-34, male, white, not married and less than high school graduate.

is significant below the 5 percent level. Controlling for industry and occupation has little effect on the magnitude of the estimated changes.[8]

The descriptive statistics indicate that the fraction of displaced workers in older age groups has increased considerably over time. In addition, displacement rates have risen for workers aged 35-54, relative to workers aged 25-34. The probit regression results indicate that the increase in the relative probability of displacement for workers aged 45-54 is significant after controlling for other factors. Changes in the probability of displacement across age groups therefore appear to have contributed to the shift in the age distribution of displaced workers. We next investigate the contribution of the aging of the labor force, increased use of computers and other technologies, and differences across age groups in industry and occupation to the changes in the age distribution of displaced workers.

Effect of Changes in the Age Distribution of the Labor Force

Changes in the age distribution of displaced workers reflect changes in the age distribution of workers as well as changes in displacement rates across age groups. We use kernel density estimation techniques to explore the effect of shifts in the age distribution of the labor force on shifts in the age distribution of displaced workers. We first present kernel density estimates of the change in the age distribution of displaced workers between 1983-87 and 1993-97. We then examine what the age distribution of displaced workers in 1993-97 would have been if the age distribution of the labor force had remained the same as it was in 1983-87.

[8] We present results with and without industry and occupation controls because the industry and occupational mix of workers may have changed during the displacement window. Industry and occupation are the pre-displacement industry and occupation for displaced workers, and the current industry and occupation for non-displaced workers. A better measure would be the industry and occupation of non-displaced workers during the three-year displacement window, which is not available. The regressions with those controls include 11 industry indicator variables and 6 occupation indicator variables, which are interacted with indicator variables for the two time periods.

Kernel density estimates, which are essentially smoothed histograms, are a nonparametric means of estimating the underlying distribution from which an empirical distribution is sampled (Valletta 1997).[9] The kernel density estimate of a univariate distribution based on a random sample $(X_1, \ldots, X_N)$ of size N with sample weights $w_1, \ldots, w_N$ is

$$\hat{f}(x) = \frac{1}{N} \sum_{i=1}^{N} \frac{w_i}{h} K\left(\frac{x - X_i}{h}\right). \quad (1)$$

In equation (1), K is the kernel function and h is the bandwidth. We use an Epanechnikov kernel and a bandwidth of 1.17, which is the bandwidth than minimizes the mean integrated squared error for the base period sample (1983-87).[10] The sample weights w_i are the CPS final weights.

Figure 1 displays the kernel density estimates of the age distribution of displaced workers during the periods 1983-87 and 1993-97. The age distribution of displacement has clearly shifted to the right over time, with older workers comprising a larger fraction of displaced workers in 1993-97 than in 1983-87. The area of non-overlap of the two curves (region A or region B) is about 11 percent of the total density, indicating that there was a sizable shift in the age distribution of displaced workers.

To estimate the effect of changes in the age distribution of the labor force on the age distribution of displaced workers, we reweighted the 1993-97 period observations in proportion to their representation in the labor force during the period 1983-87. Using data from the CPS outgoing rotation groups, we calculated the fraction of persons in the labor force for each single year of age relative to the number of persons in the labor force aged 25-54. This calculation was done for the periods 1983-87 and 1993-97. We then multiplied the sample weights for individuals in the 1993-97 sample by the ratio of the fraction of the labor force in a single-year

[9] For a nontechnical discussion of kernel density estimation, see Johnston and DiNardo (1997). For a more technical approach, see Silverman (1986).

age group during 1983-87 to the fraction of the labor force in a single-year age group during 1993-97, or

$$reweight_i = w_i * \left(\frac{\%laborforce^{a}_{1983-87}}{\%laborforce^{a}_{1993-97}} \right), \quad (2)$$

where *a* is the age of individual *i*. The adjusted weights are then used in equation (1) for individuals in the 1993-97 sample. Because a larger fraction of the labor force was in older age groups during 1993-97 than during 1983-87, this reweighting scheme effectively increases the weight of younger workers and decreases the weight of older workers in the later period.

Figure 2 displays the results. The age distribution of displaced workers in 1993-97 is now considerably more similar to the age distribution of displaced workers in 1983-87 than in Figure 1. The area of the non-overlap region in Figure 2 is about 4 percent, compared to 11 percent in Figure 1. Changes in the age distribution of the labor force thus appear to account for nearly two-thirds of the shift in the age distribution of displaced workers.

These results suggest that changes in the age distribution of the labor force account for most of the observed change in the age distribution of displaced workers. However, differences remain between the age distributions of the 1983-87 data and the reweighted 1993-97 data, indicating that the relative likelihood of displacement for older workers also increased over time. We next examine whether several specific factors played a role in the shift in the age distribution of displaced workers by increasing the relative probability of displacement among older workers.

[10] The results are similar if other bandwidths are used, such as the variance-minimizing bandwidth for the 1993-97 period or the variance-minimizing bandwidth for the 1983-87 and 1993-97 periods combined.

Effect of Technological Change

Changes in technology that have made older workers' specific human capital less valuable to employers may have contributed to the increase in the relative likelihood of displacement for older workers. Technology could account for the shifts in the age distribution of displaced workers in two ways. First, increased use of computers and other forms of technology could cause displacement of older workers to increase relative to younger workers; an increase in use of technology between 1983-87 and 1993-97 would then contribute to the increase in the fraction of displaced workers who are older. Second, the relationship between displacement, age and technology could have changed over time, with older workers more likely to be displaced than younger workers for a given level of technological intensity in the 1990s than in the 1980s. We examine what the age distribution of workers displaced during 1993-97 would have looked like if technology usage and the relationship between displacement, age and technology had remained the same as in 1983-87.

We use the fraction of workers in an industry who report using a computer at work as a proxy for technology. Using questions in the October 1984 and October 1993 CPS supplements about computer usage at work, we measure the fraction of workers who report using a computer at work for 50 different industry groups. These computer usage rates are then merged with the DWS sample by industry. The October 1984 CPS computer usage rates are merged with the 1986 and 1988 DWS data, and the October 1993 computer usage rates are merged with the 1996 and 1998 DWS data.[11] We use computer usage rates from near the beginning of the sample periods to minimize the possibility that changes in displacement rates lead to changes in computer usage, instead of vice versa.

Table 4 reports the mean computer usage rate for workers by age and displacement status for the two periods. Average computer usage rates clearly are higher during 1993-97 than during 1983-87. The average computer usage rate is lower for the industries in which displaced workers were employed than for the industries employing nondisplaced workers. Workers aged 25-34 tend to work in industries with a slightly lower average computer usage rate than did older workers.

To examine the relationship between displacement, age and technology, we estimate probability models of displacement that include the measure of computer usage. The computer usage variable, which measures the fraction of workers in an industry who use a computer, captures the relationship between the probability that a worker is displaced and the computer usage rate in that worker's industry. In addition, the probit regressions include interactions of the age variables with the computer usage variable. If older workers are more likely to be displaced in industries that are more computer-intensive than are younger workers, the interaction terms should be positive. The regressions also include the variables listed in Table 3. All of the variables are interacted with two time period indicator variables to allow the estimated coefficients to differ for 1983-87 and 1993-97.

Table 5 reports the estimated marginal coefficients, evaluated at the sample means, from the probit regressions. As in Aaronson and Housinger (1999), we find that the likelihood of displacement is negatively associated with computer usage rates, and the relationship tends to weaken when industry and occupation controls are included. When industry and occupation controls are included in the regression, the relationship between the probability of displacement and computer usage weakens over time.

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[11] Unlike Addison, Fox and Ruhm (1996) and Aaronson and Housinger (1999), we use a time-varying measure of technological intensity. This allows us to examine the effects of changes over time in technological use as well

The results suggest that technological change, as measured by computer usage rates, may have contributed to the increase in displacement of older workers, relative to younger workers. During 1983-87, the interactions of the age variables with the computer usage variable are not significant. During 1993-97, in contrast, the likelihood of displacement rose with an industry's computer usage rate for workers aged 35-54, relative to workers aged 25-34. The changes in the estimated coefficients of the variables interacting age and computer usage are not statistically significant (columns 4 and 6), but they suggest that technology, as proxied by computer usage, may have played a role in the shift in the age distribution of displaced workers.

We use kernel density estimation techniques to further investigate the effect of technological change on the age distribution of displaced workers. We estimate what the age distribution of workers displaced during 1993-97 would have been if computer usage rates and the relationship between displacement, age and computer usage had remained the same as in 1983-87. Two predicted probabilities of displacement for workers who were displaced during 1993-97 are necessary to estimate this counterfactual age distribution: the predicted probability of displacement given computer usage rates in 1984 and the relationship between displacement, age and computer usage during 1983-87; and the predicted probability of displacement given computer usage rates in 1993 and the relationship between displacement, age and computer usage during 1993-97.

These predicted probabilities are estimated using probit regressions. First, a probit model for the probability of displacement among all workers in the 1993-97 sample is estimated. The regression, which is similar to Table 5, includes computer usage rates from the October 1993 CPS. The results of this probit regression are used to predict the probability of displacement for workers displaced during 1993-97, which is the denominator of the adjusted weight. A separate

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changes over time in the relationship between displacement and technology.

probit model is estimated among all workers in the 1983-87 sample and includes computer usage rates from the October 1984 CPS. Workers displaced during 1993-97 are assigned the computer usage rates for their industries in the October 1984 CPS, and the estimated coefficients from the 1983-87 probit regression are used to predict the probability of displacement for each worker displaced during 1993-97. This predicted probability is the numerator of the adjusted weight.

The ratio of these predicted probabilities are then used to create an adjusted weight for the kernel density. Equation (1) is reestimated for workers displaced during 1993-97 with the adjusted weights

$$reweight_i = w_i * \left(\frac{prob(displacement \mid comp = 1984, \hat{\beta}_{1983-87})}{prob(displacement \mid comp = 1993, \hat{\beta}_{1993-97})} \right), \quad (3)$$

where the probabilities are predicted as described above and w_i is individual i's CPS final weight.

Figure 3 displays the results. The reweighted data for the period 1993-97 show an age distribution of displaced workers more similar to the age distribution of workers displaced during 1983-87 than in Figure 1, the unadjusted data. The area of non-overlap of the two distributions in Figure 3 is about 9 percent of the density, compared to 11 percent in Figure 1 and 4 percent in Figure 2. Changes in computer usage rates and in the relationship between displacement, age and computer usage appear to underlie about one-fifth of the shift in the age distribution of displaced workers.

In results not reported here, we also used several other measures of technological change to examine the relationship between displacement, age and technology. Other measures of technological intensity include computer investment as a fraction of total investment, scientists and engineers as a fraction of total employment, and research and development funds as a

fraction of sales (Bartel and Sicherman 1999; Berman, Bound and Griliches 1994). Using time-varying values of these variables yielded kernel density estimates of the age distribution of displaced workers similar to our estimated density based on computer usage rates; the scientists and engineers variable accounted for about two-fifths of the difference in the distributions, while the computer investment ratio and research and development to sales ratio accounted for about one-third of the difference in the distributions.[12]

Effect of Changes in Industry and Occupation

Differences across age groups in industry and occupation are other potential contributors to the shift in the age distribution of displacement. During the sample period, older workers may have been employed in different industries and occupations than younger workers. In particular, older workers may have been more likely than younger workers to be employed in industries with high displacement rates during 1993-97, or in occupations with high displacement rates, relative to industry and occupation patterns during 1983-87. Because displacement rates are higher in the goods-producing sector than in the service sector, and higher in blue-collar jobs than in white-collar jobs (Kletzer 1998), an increased concentration of older workers in blue-collar, goods-producing jobs may have contributed to the shift in the age distribution of displaced workers.

[12] Scientists and engineers as a fraction of total employment in an industry was measured using the CPS outgoing rotation groups data for 1983 and 1993 for the same 50 industries as the computer usage rate variable. Computer investment as a fraction of total new investment was measured using data from the 1982 and 1992 Census of Manufacturers for 76 industries within the manufacturing sector. The ratio of research and development funds to sales data for 1983 and 1993 is from the National Science Foundation (1996) for 19 industries within the manufacturing sector. The computer investment ratio and research and development to sales ratio may have accounted for a greater fraction of the change in the age distribution because the data are only available for the manufacturing industry; those kernel density estimates were calculated using only workers displaced from manufacturing.

Table 6 reports the fraction of workers in the sample employed in goods-producing industries and in blue-collar occupations during 1983-87 and 1993-97.[13] Goods-producing industries accounted for a smaller fraction of employment during 1993-97 than 1983-87, declining from 32 percent to 27 percent of employment. Similarly, the fraction of workers in blue-collar occupations fell from 42 during 1983-87 to 39 percent during 1993-97. The fraction of displaced workers who were employed in goods-producing industries and in blue-collar jobs is higher than the fraction of non-displaced workers during both periods, indicating that displacement rates were higher in goods-producing industries than in service-producing industries and higher in blue-collar occupations than in white-collar occupations.

If older workers were more likely to be employed in goods-producing industries (or blue-collar occupations) during 1993-97, relative to 1983-87, than were younger workers, changes across age groups in industry or occupation may have contributed to the change in the age distribution of displacement. The summary statistics in Table 6 suggest that this may not be the case. The fraction of workers aged 45-54 employed in goods-producing industries fell more than did the fraction of workers aged 25-34; however, the fraction of workers aged 35-44 employed in goods-producing industries did not decline relative to the change among workers aged 25-34. A similar pattern holds for the fraction of workers employed in blue-collar occupations within age groups.

We use conditional weighted density estimation techniques to further examine the effect of changes in the distribution of workers of different ages between goods-producing and service-

[13] Goods-producing industries include agriculture, mining, construction and manufacturing (service-producing industries include transportation, communications and public utilities, wholesale and retail trade, finance, insurance and real estate, services and public administration). Blue-collar occupations include service occupations, farming, forestry and fishing occupations, precision production, craft and repair occupations, and operators, fabricators and laborers (white-collar occupations include managerial and professional specialty occupations, technical, sales, and administrative support occupations). The pre-displacement industry and occupation are used for displaced workers and the current industry and occupation for non-displaced workers.

producing industries and between white-collar and blue-collar occupations. This technique estimates what the age distribution of displaced workers would have been during 1993-97 if the distribution of workers across goods-producing and service-producing industries were the same as it was during 1983-87, conditional on individual characteristics. In the first step, probit models of the likelihood that a worker was employed in the goods-producing sector are estimated separately for the periods 1983-87 and 1993-97 using data on all workers aged 25-54 from the CPS outgoing rotation groups data.[14] The next step uses the estimated coefficients to predict the probability of being employed in the goods-producing sector during each period for workers displaced during 1993-97. The CPS sample weights of workers displaced during 1993-97 are then multiplied by the ratio of the predicted probabilities in 1983-87 and 1993-97. The weights in the kernel density estimate given in equation (1) for workers displaced during 1993-97 are replaced with

$$reweight_i = w_i * \left(\frac{prob(goods - producing \,|X, \hat{\beta}_{1983-87})}{prob(goods - producing \,|X, \hat{\beta}_{1993-97})} \right), \tag{4}$$

where X is displaced worker i's characteristics, β is the estimated coefficients for the two periods, and w is the CPS final weights. Implicitly, workers who are more likely to have been in the goods-producing sector in 1983-87 than in 1993-97 are upweighted, and individuals who are more likely to have been in the service-producing sector in 1983-87 than in 1993-97 are downweighted. The analysis is similar for shifts from blue-collar to white-collar occupations.

The results suggest that changes in the broad industry and occupational distribution of workers have had little effect on the age distribution of displaced workers. When changes between employment in goods-producing and service-producing industries are controlled for

[14] The individual characteristics included in the regressions are age and its square, 4 of 5 education dummy variables, female, married, nonwhite, and 3 of 4 region dummy variables.

using the conditional weighted density technique, the difference in the age distributions of displaced workers in 1983-87 and 1993-97 is about 10 percent. In Figure 1, in comparison, the difference in the distributions is about 11 percent of the density. Controlling for changes in employment in blue-collar and white-collar jobs also yields a difference in the age distributions of displaced workers in 1983-87 and 1993-97 of about 10 percent. This suggests that industry and occupation shifts played a minor role in the shift in the age distribution of displaced workers, each accounting for less than one-tenth of the shift observed in Figure 1.

Summary

This analysis used data from the 1986, 1988, 1996 and 1998 Displaced Worker Surveys to examine whether the age distribution of displaced workers has changed over time. The results indicate that older workers comprised a larger fraction of displaced workers during 1993-97 than during 1983-87. The incidence of displacement also rose among workers aged 35-54 relative to workers aged 25-34. These findings are consistent with anecdotal evidence that the middle-aged workers are more likely to be displaced during the 1990s than during the 1980s. However, the incidence of displacement remained lower among older workers than among younger workers.

Much of the shift in the age distribution of displaced workers appears due to the aging of the labor force. When many baby boomers were in their late 20s and 30s during the 1980s, a large proportion of displaced workers were also in those age groups. As many baby boomers moved into their late 30s and 40s during the 1990s, the age distribution of displaced workers shifted toward older workers. The aging of the labor force appears to account for about two-thirds of the shift in the age distribution of displaced workers. Changes in technology, such as increased use of computers in the workplace, appear to have contributed to the relative increase

in the likelihood of displacement of older workers, relative to younger workers. Our estimates suggest that technological change may account for about one-fifth of the shift in the age distribution of displaced workers. Differential changes across age groups in the industry and occupation mix of jobs appear to have a minor effect on the age distribution of displaced workers.

Other factors may have also contributed to the observed shift in the age distribution of displaced workers. For example, age discrimination against older workers may have become more prevalent. Older workers may be more expensive than younger workers, relative to their marginal productivity, and increased pressure for firms to cut costs may have raised the fraction of displaced workers who are older. These are areas for future research.

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Table 1
Summary Statistics, by Displacement Status and Period

	1983-87			1993-97		
Variable	All	Displ.	Not Displ.	All	Displ.	Not Displ.
Displaced	.076	--	--	.074	--	--
Age:						
Age 25-34	.426	.497	.420	.336	.380	.332
Age 35-44	.345	.318	.347	.380	.370	.381
Age 45-54	.229	.184	.232	.284	.250	.286
Sex:						
Male	.553	.625	.547	.534	.553	.532
Female	.447	.376	.453	.466	.447	.468
Race:						
White	.864	.851	.865	.849	.841	.849
Nonwhite	.136	.149	.135	.151	.159	.151
Marital Status:						
Married	.690	.636	.694	.661	.586	.667
Not married	.310	.364	.306	.339	.414	.333
Education:						
Not high school grad.	.128	.184	.123	.090	.121	.087
High school graduate	.370	.414	.366	.317	.332	.316
Some college	.237	.243	.237	.288	.313	.286
College graduate	.144	.100	.148	.205	.171	.208
Post graduate	.121	.060	.126	.100	.063	.103
Number of obs. (unweighted)	96857	9028	87829	75459	5459	70000

Notes: Shown are weighted sample means. The 1983-87 sample includes workers from the 1986 and 1988 DWSs, and the 1993-97 sample includes workers from the 1996 and 1998 DWSs. Workers are considered displaced if they reported losing or leaving a job because of plant closure, job abolished, or slack work in the three years prior to the survey. Observations are weighted using the sample final weights.

Source: Authors' calculations from CPS DWSs.

Table 2
Incidence of Displacement, by Characteristics and Period

Variable	1983-87	1993-97	Diff.
Age:			
Age 25-34	.088	.083	-.005
Age 35-44	.070	.072	.002
Age 45-54	.061	.065	.004
Sex:			
Male	.085	.076	-.009
Female	.064	.071	.007
Race:			
White	.074	.073	-.001
Nonwhite	.083	.077	-.006
Marital Status:			
Married	.070	.065	-.005
Not married	.089	.090	-.001
Education:			
Not high school grad.	.109	.099	-.010
High school graduate	.085	.077	-.008
Some college	.077	.080	.003
College graduate	.052	.061	.009
Post graduate	.038	.046	.008

Notes: Shown are the fraction of workers who report being displaced among workers with the given characteristic. The 1983-87 sample includes workers from the 1986 and 1988 DWSs, and the 1993-97 sample includes workers from the 1996 and 1998 DWSs. Workers are considered displaced if they reported losing or leaving a job because of plant closure, job abolished, or slack work in the three years prior to the survey. Observations are weighted using the sample final weights.

Source: Authors' calculations from CPS DWSs.

Table 3
Probit Estimates of the Probability of Displacement

	(1)			(2)		
Covariate	1983-87	1993-97	Diff.	1983-87	1993-97	Diff.
Age 35-44	-.013	-.008	.005	-.011	-.006	.005
	(.002)	(.002)	(.003)	(.002)	(.002)	(.003)
Age 45-54	-.024	-.012	.011	-.020	-.009	.011
	(.002)	(.002)	(.003)	(.002)	(.002)	(.003)
Female	-.022	-.006	.016	.001	.008	.007
	(.002)	(.002)	(.002)	(.002)	(.002)	(.003)
Nonwhite	.0005	-.0001	-.0006	.0003	.0015	.0012
	(.0026)	(.0024)	(.0035)	(.0025)	(.0023)	(.003)
Married	-.017	-.020	-.003	-.016	-.018	-.002
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
High school graduate	-.016	-.016	.001	-.008	-.011	-.003
	(.002)	(.003)	(.004)	(.002)	(.003)	(.004)
Some college	-.024	-.014	.010	-.007	-.002	.004
	(.002)	(.003)	(.004)	(.003)	(.003)	(.004)
College graduate	-.042	-.030	.012	-.020	-.010	.009
	(.002)	(.002)	(.003)	(.003)	(.003)	(.004)
Post graduate	-.052	-.040	.012	-.022	-.012	.011
	(.002)	(.002)	(.003)	(.003)	(.004)	(.005)
1993-97	--	--	.007	--	--	.030
			(.005)			(.012)
Industry and occupation dummy variables			No			Yes
Log likelihood			-44911			-43725

Notes: Shown are marginal probit coefficients, evaluated at the sample means. The 1983-87 sample includes workers from the 1986 and 1988 DWSs, and the 1993-97 sample includes workers from the 1996 and 1998 DWSs. Workers are considered displaced if they reported losing or leaving a job because of plant closure, job abolished or slack work in the three years prior to the survey. The first three columns are estimated from one regression, and the other three columns from a separate regression. The reference categories are age 25-34, male, white, unmarried, not high school graduate. Regressions also include 3 of 4 region dummy variables,

interacted with dummy variables for the two periods. Observations are weighted using the sample final weights.

Source: Authors' calculations from CPS DWSs.

Table 4
Summary Statistics of Computer Usage Rate, by Age, Displacement Status and Period

	1983-87			1993-97		
Variable	All	Displ.	Not Displ.	All	Displ.	Not Displ.
All ages	.255	.230	.257	.468	.436	.470
Age 25-34	.251	.227	.253	.458	.421	.462
Age 35-44	.261	.234	.263	.466	.438	.469
Age 45-54	.255	.231	.256	.481	.454	.483

Notes: Shown are weighted sample means of the fraction of workers in an industry who report using a computer at work. The computer usage rates are for 50 industries. The computer usage rates for the 1983-87 sample are from the October 1984 CPS, and the computer usage rates for the 1993-97 sample are from the October 1993 CPS. Observations are weighted using the sample final weights.

Source: Authors' calculations from CPS.

Table 5
Probit Estimates of the Effect of Computer Usage on Probability of Displacement

	(1)			(2)		
Covariate	1983-87	1993-97	Diff.	1983-87	1993-97	Diff.
Age 35-44	-.009	-.015	-.006	-.009	-.015	-.005
	(.004)	(.004)	(.006)	(.004)	(.004)	(.005)
Age 45-54	-.022	-.021	.002	-.019	-.019	.0002
	(.004)	(.005)	(.006)	(.004)	(.004)	(.0057)
Computer usage rate in industry	-.042	-.054	-.012	-.045	-.021	.025
	(.009)	(.007)	(.012)	(.011)	(.009)	(.015)
Age 35-44 * computer usage rate	-.013	.019	.032	-.006	.022	.028
	(.014)	(.010)	(.017)	(.014)	(.010)	(.017)
Age 45-54 * computer usage rate	-.004	.023	.027	-.001	.026	.027
	(.017)	(.011)	(.020)	(.016)	(.010)	(.019)
1993-97	--	--	.018	--	--	.026
			(.006)			(.014)
Industry and occupation dummy variables			No			Yes
Log likelihood			-44840			-43709

Notes: Shown are marginal probit coefficients, evaluated at the sample means. The first three columns are estimated from one regression, and the other three columns from a separate regression. The reference category for age is age 25-34. Regressions also include interactions of dummy variables for the two periods with dummy variables for female, nonwhite, married, 4 of 5 education groups, and 3 of 4 regions. Observations are weighted using the sample final weights.

Source: Authors' calculations from CPS DWSs.

Table 6
Industry and Occupational Distribution, by Age, Displacement Status and Period

	1983-87			1993-97		
Variable	All	Displ.	Not Displ.	All	Displ.	Not Displ.
Goods-producing industries						
All, aged 25-54	.318	.538	.300	.272	.368	.265
Age 25-34	.322	.527	.303	.271	.346	.264
Age 35-44	.306	.539	.289	.281	.386	.273
Age 45-54	.326	.568	.310	.262	.376	.254
Blue-collar occupations						
All, aged 25-54	.417	.570	.405	.388	.460	.383
Age 25-34	.440	.593	.425	.403	.486	.395
Age 35-44	.392	.564	.380	.397	.464	.392
Age 45-54	.413	.520	.407	.360	.413	.357

Notes: Shown are the fraction of workers in a given age group and displacement status employed in goods-producing industries or blue-collar occupations. The industry and occupation at the pre-displacement job are used for displaced workers, and the current industry and occupation for non-displaced workers. Observations are weighted using the sample final weights.

Source: Authors' calculations from CPS DWSs.

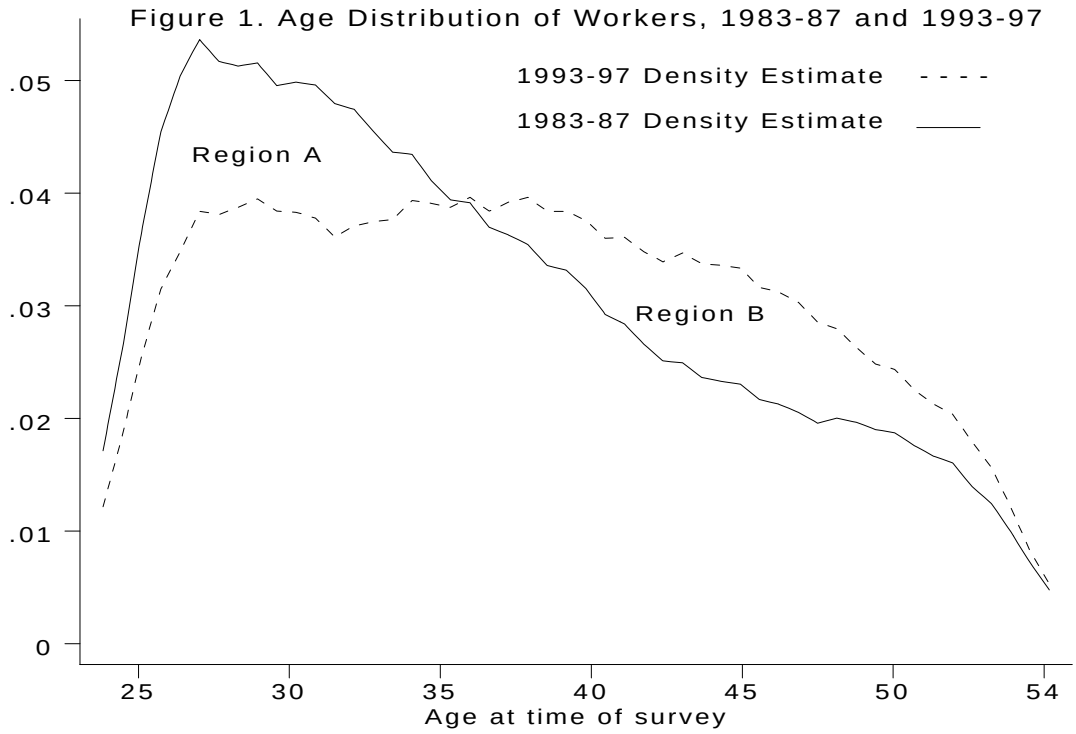
Figure 1. Age Distribution of Workers, 1983-87 and 1993-97
1993-97 Density Estimate
1983-87 Density Estimate
Region A
Region B
.05
.04
.03
.02
.01
0
25
30
35
40
45
50
54
Age at time of survey

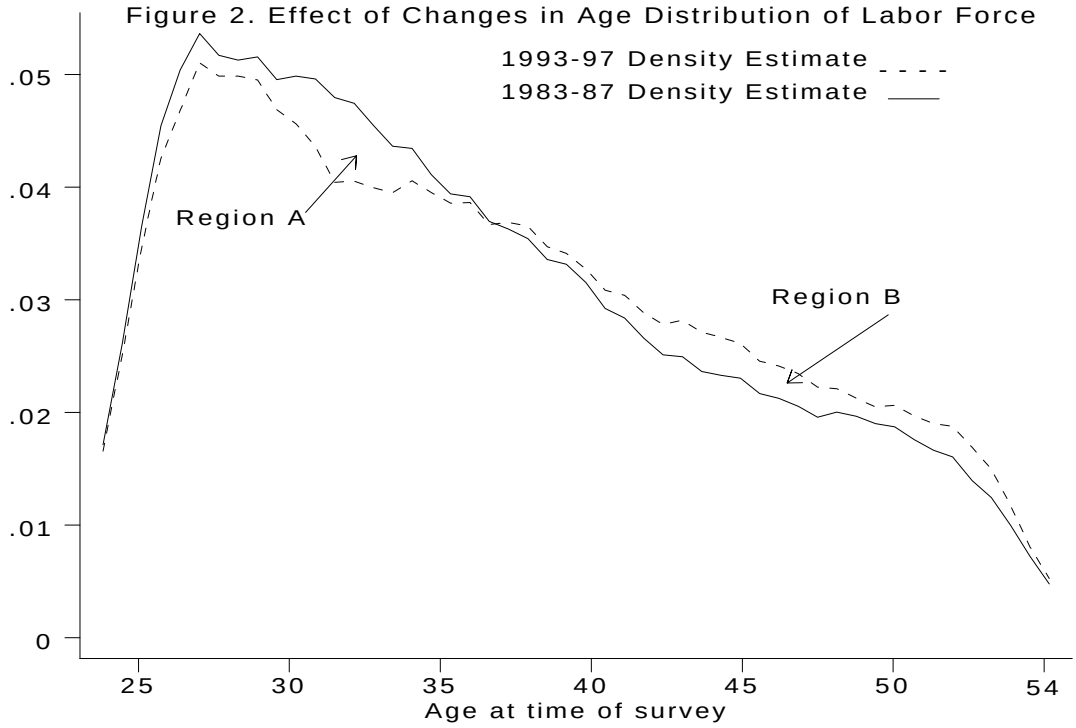
Figure 2. Effect of Changes in Age Distribution of Labor Force
1993-97 Density Estimate
1983-87 Density Estimate
.05
.04
.03
.02
.01
0
Region A
Region B
25
30
35
40
45
50
54
Age at time of survey


Figure 3. Effect of Computer Usage on the Age Distribution of Displaced Workers, 1983-87 and 1993-97
1993-97 ---
1983-87 ——
Region A
Region B
.05
.04
.03
.02
.01
0
25
30
35
40
45
50
54
Age at time of survey
Stata™