

# The Lost Generation? Scarring after the Great Recession

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## Abstract:

I investigate medium- and long-term impacts of the Great Recession on post-recession college graduates. Most “scarring” models emphasize effects of initial conditions that attenuate over the first decade of a worker’s career. But early career recessions may also have permanent effects. I decompose the recent cohorts’ experience into transitory time effects, medium-term scarring, and permanent cohort effects. Cohort effects are strongly cyclical. Medium-term scarring explains only half of this cyclical. The long-run cumulative effect of the recession on graduates’ employment is more than twice as large as the immediate effect.

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## I. Introduction

The Great Recession was unusually severe and, in the labor market, long lasting. The unemployment rate rose from 4.4 percent in May 2007 to 10.0 percent in October 2009, and the prime-age employment-to-population ratio fell by 5.5 percentage points. The unemployment rate did not reach 4.4 percent again until March 2017, while employment has yet to fully recover.

Where most older workers can weather a weak labor market by remaining in their existing jobs, students leaving school must find new jobs to work. Job openings were at least 20% below their pre-recession peak for nearly five years, and the hiring rate remained significantly depressed until late 2014. The share of individuals aged 20-25 who were neither working nor in school rose by nearly half, from 13.1% in 2007 to a high of 19.0% in 2013.

Prolonged unemployment may have long-run consequences for individuals' employability and productivity. Yagan (forthcoming) finds that experienced workers who faced more severe local shocks during the Great Recession had lower employment rates even after their local labor markets had recovered. Hysteresis effects may be even larger for young workers, for whom graduating in a recession may mean reduced access to valuable on-the-job experience and training. Evidence from past business cycles indicates that those who enter the labor market during downturns are "scarred" for many years thereafter, with lower employment and wages than similar individuals from cohorts that entered at better times (Kahn 2010; Oreopolous, von Wachter, and Heisz 2012; Schwandt and von Wachter, 2019).

I use data on the labor market outcomes of young people during and after the 2007-9 Great Recession to obtain a preliminary measure of the medium- and long-run scarring effects of

the deep, extended downturn on new entrants' labor market outcomes. Following the existing scarring literature, I focus on college graduates, whose human capital is unlikely to have become technologically obsolete during the downturn.

I find that the employment, annual earnings, and hourly wages of those who entered the labor market during and after the recession are lower than would be expected given the experience of older cohorts in the same market. College graduates who entered the labor market in 2010 and 2011 have employment rates two percentage points lower than the age- and time-adjusted employment rates of pre-recession cohorts, and those who work have annual earnings that are two percent lower. Employment declines persist for even the most recent labor market entrants, while annual earnings effects have recovered for post-2012 entrants and persistent wage effects are seen for only the 2009 entering cohort. Focusing on the employment results, in a simple age-time-cohort decomposition I find that pure time effects account for only about half of the decline for cohorts entering the labor market in 2009-2011, and none of the decline for cohorts entering later. The remainder is attributed to cohort effects, as post-recession cohorts continue to do poorly even in more recent data when older cohorts have recovered.

I next investigate whether existing models of scarring can account for the ongoing weak employment and earnings outcomes. An important feature of the specifications that have typically been estimated is that scarring effects, while long lasting, are not permanent. The effects of the initial employment rate are frequently estimated to dissipate by the individual's 10<sup>th</sup> year in the labor market (Borgschulte and Martorell 2018; Kahn 2010; Oreopoulos et al. 2012). Thus, insofar as these models correctly characterize the scarring effect of the Great

Recession, they imply that much of the damage to the post-recession cohorts has already been borne, and that the Recession will not cast a large shadow going forward.

I reproduce scarring estimates on employment in Current Population Survey data, using similar specifications to those used by previous authors. Post-Great-Recession scarring is closely in line with extrapolations of estimates based on pre-2007 data. Whether I use the full sample or just the pre-recession subsample, I find substantial medium-term scarring that fades out over several years. However, it can account for only about half of the depressed employment of the post-recession cohorts, relative to other cohorts in the post-recession labor market. The remaining half of the employment effect is attributed to cohort changes. I show that cohort effects, which have generally been treated as nuisance parameters in past scarring work (e.g., Oreopoulos et al., 2012), are cyclical, lower for cohorts that graduate in recessions. By the logic of the specification, cohort effects are permanent, so the damage done by recessions through this channel lasts throughout the affected cohorts' careers.

I close with a calculation of the contribution of these long-lasting effects to the total cumulative impact of the Great Recession, extrapolating the cohort-level shock through the decades remaining in the affected cohorts' potential careers. I estimate that through a combination of short-, medium-, and long-run effects, the Great Recession will reduce the employment rates of college graduates over the 2007-2060 period by a total of over 15 percentage point-years. Just a bit more than half of this loss was incurred during the 2007-2014 period when the unemployment rate was elevated, while the remainder reflects medium- and long-term effects of the recession. The medium-term effects, due to scarring, will gradually fade over the next few years, while the long-run effects will persist as long as the recession cohorts

remain in the labor market. These are quantitatively important: Effects that will manifest after 2025 account for nearly one-third of the total damage.

This evidence complements Yagan's (forthcoming) evidence of persistent effects on incumbent workers, and supports the view that hysteresis is an important component of the welfare cost of business cycles. The long-run impacts on new entrants represent a sizeable overhang of the downturn that will reduce prosperity for decades to come. DeLong and Summers (2012) argue that this kind of shadow constitutes a quantitatively important component of the true cost of recessions, and that if post-recession hangovers are large enough counter-cyclical fiscal policies can be self-financing. My estimates of the scarring effects of the recession on new labor market entrants capture only a small component of potential hysteresis, but are on their own large enough to imply a meaningful fiscal offset for countercyclical policies.

## **II. The Great Recession in the labor market**

The unemployment rate rose by 6.5 percentage points between mid-2007 and late-2009, more than during any earlier post-war business cycle (Appendix Figure A-1). It then declined roughly linearly after mid-2010. It has been below 6% since the third quarter of 2014 and below its pre-recession level since early-2017.

The prime-age (25-54) employment rate fell by over five percentage points by late 2009, and was much slower to recover than the unemployment rate. At this writing the employment rate is 82.3%, still about 0.5 point below the lowest level seen after the early-2000s recession and a full point below the 2007 peak.

Young people fared particularly poorly during the downturn. The first panel of Figure 1 shows the employment rate separately for those aged 25-30 and those aged 31-54. While the two series generally rise and fall together, the amplitude is much larger for young workers, whose employment fell more than five percentage points during the Great Recession. The second panel distinguishes college graduates and non-graduates within the youngest group. Employment rates are higher and less cyclical for college graduates. However, their employment rate declined substantially during the recession, and was very slow to recover thereafter. By the end of 2014, the non-graduates had made up about one-third of the ground lost during the recession, while young graduates' employment was still *below* its end-of-recession level.

Wages do not respond flexibly to fluctuations in labor demand (Bewley 1999). Nevertheless, one can also see the impact of the downturn in average wages. Figure A-2 shows average real hourly wages for the same groups broken out in Figure 1. All four mean wage series fell after the recession (though not during it, due to changes in the composition of workers; see Daly, Hobijn, and Wiles 2012), with a larger decline for younger workers and similar declines for young graduates and non-graduates. Older workers' wages have more than recovered in recent years, but young workers' wages, both graduates' and non-graduates', have only approached their 2007 local maxima and remain well below their 2000 peaks.

### **III. Scarring and hysteresis**

An influential literature examines the persistent effects of labor market conditions at the time of college graduation (e.g., Kahn 2010; Oreopoulos et al. 2012; Schwandt and von Wachter, 2019; Borgschulte and Martorell 2018; Oyer 2006, 2008). This research generally finds sizable

persistent effects on wages that fade out over the first decade following graduation.<sup>1</sup> One interpretation is that new graduates are delayed in beginning to climb up the job ladder during recessions; another is that labor market weakness at career start translates into a weak bargaining position for many years thereafter (Beaudry and DiNardo 1991). Many of the specifications used in this work (e.g., Oreopoulos et al. 2012) include cohort effects as controls, but focus on interactions between the entry unemployment rate and early-career potential experience indicators, treating the cohort effects as nuisance parameters. In contrast, I emphasize these effects as key components of the persistence of recession impacts.

These so-called “scarring” studies are only a small component of an immense literature examining hysteresis more generally. Clark and Summers (1982) conclude participation is fairly persistent: “Workers drawn into the labour force by cyclical upturns tend to remain even after the boom has ended. The converse is true for shocks which reduce employment,” (p. 842). Yagan (forthcoming) finds that workers who lived in areas that experienced larger Great Recession shocks had worse outcomes 6-8 years later, not attenuated by mobility to healthier labor markets. My analysis complements Yagan’s by examining young workers – his estimates are based on workers already over 30 in 2007 – and relating the persistent impacts of the Great Recession to those of pre-2007 fluctuations.

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<sup>1</sup> Another relevant literature examines the effects of job displacement on subsequent earnings (Jacobson, LaLonde, and Sullivan 1993; von Wachter and Bender 2006; Schmieder, von Wachter, and Heining 2018). Again, these studies typically find persistent effects that fade out only over a long period. Davis and von Wachter (2012) find that the displacement effect is larger in recessions.

#### IV. Data

I use repeated cross section data from several components of the Current Population Survey (CPS) to examine individuals born between 1948 and 1995 and observed at ages 22 to 40 between 1979 and 2018. I estimate many models on those who had fully entered the labor market before the 2007 recession; for these, I limit the sample to those born by 1978.

My primary outcome is the employment rate of young workers, measured in the monthly CPS. I also analyze log real annual earnings, measured in the Annual Social and Economic Supplement (the March CPS), and log real hourly wages, from the CPS Outgoing Rotation Group (ORG), for those with positive earnings (annual or weekly, respectively). Data processing and definitions are discussed in the Appendix.

For each outcome and sample, I aggregate to the education-state-year-cohort cell mean.<sup>2</sup> I use two education groups: Bachelor's degrees and above, and less than a BA. Following the scarring literature, I focus on the former, but I present results for the latter as well. I merge onto each cell the contemporaneous state unemployment rate and the unemployment rate at labor market entry.<sup>3</sup>

There are three important limitations to the CPS data for my purposes. First, I do not observe the date that a respondent first searched for work. Following the scarring literature, I assume that the unemployment rate at age 22 (18 for non-college-graduates) is the relevant initial condition.

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<sup>2</sup> Birth cohorts are approximated by subtracting the age as of the CPS interview from the year of the survey. They are off by one for respondents who have not yet had their birthdays.

<sup>3</sup> State unemployment rates are available only from 1976; for cohorts that entered the labor market before this date, I use the national rate.



Second, I observe only the respondent's current state of residence, not the state where he/she lived at labor market entry. Schwandt and von Wachter (2019) explore the bias in similar specifications from failing to measure location as of graduation, and conclude that it is "unlikely to be very large." I explore sensitivity to mobility in the Appendix.

Third, when I observe someone at age 23 I do not know whether he/she will earn a degree at 26. Thus, my education-specific mean outcomes are based on populations that are selected differently at young than at older ages. Figure A-3 shows the share of the CPS sample with a bachelor's degree by birth cohort (in two-year bins) and year. The degree attainment rate for 22-year-olds is only half or one-third of what will be seen for the same cohort at age 30. For cohorts born in the 1960s, the great majority of degrees were earned by age 24. There was a substantial increase in post-24 degree attainment around the 1968 birth cohort, which turned 22 in 1990 (Bound, Lovenheim, and Turner 2012), but still the great majority of degrees are awarded by 26. Since the mid-1990s, final attainment has grown substantially, particularly for cohorts turning 22 during and after the Great Recession, but most of the growth is in degrees awarded by age 24.<sup>4</sup> Together, these facts make it plausible that age effects will absorb most of the bias in the cohort mean outcomes averaged across various ages.

I take two approaches to dealing with remaining bias from changing composition of the college graduate subgroup over cohorts and years. First, I include in my regression specifications an inverse Mills ratio computed from the cohort-by-age attainment rate (or, for non-graduates,

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<sup>4</sup> In the final data points there is an indication that post-24 degrees are growing for post-2010 entrants. It will be several years until we can fully measure this, and in the meantime it has little impact on my CPS samples.

from the complement of this). The coefficient on this control is identified solely from changes in the attainment rate over age that differ across cohorts. In a simple bivariate normal selection model, this will absorb any bias from changing selection (Gronau 1974, Card and Rothstein 2007). Second, I have reestimated my primary specifications excluding observations from ages under 24. Results are largely unchanged.

## V. Methods and results

### A. Age-time-cohort decomposition

My basic analytical method is an age-time-cohort decomposition. Let  $Y_{satc}$  represent the employment rate of college graduates in state  $s$  at age  $a$  in time  $t$  from birth cohort  $c$  (indexed by the year that the group entered the labor market, or  $c=t-a+22$ ). I estimate models of the form:

$$Y_{satc} = \alpha + \beta_t + \gamma_a + \delta_c + \zeta_s + \rho\lambda(p_{atc}) + \epsilon_{satc}. \quad (1)$$

Here,  $\beta_t$  are a set of fixed effects for years,  $\gamma_a$  are age effects, and  $\delta_c$  are birth cohort fixed effects.  $\zeta_s$  represent state effects, while  $\lambda(\cdot)$  is the inverse Mills function applied to the state-cohort-age attainment rate,  $p_{atc}$ . The time effects include both aggregate demand and any supply-side factors that are common across age groups, such as the hysteresis effects documented by Yagan (forthcoming). Cohort effects are permanent, and capture any differences between one birth cohort and another in the same labor market, beyond those reflected in the age profile  $\gamma_a$ .

The linear trends in the age, time, and cohort effects are not separately identified. I normalize the cohort effects for the 1991 and 2000 entry cohorts (born in 1969 and 1978, respectively) to be the same.

I am interested in the degree to which poor employment rates of young graduates following the 2007-9 Great Recession can be attributed to transitory demand shocks, captured by  $\beta_t$  in equation (1), versus permanent differences between post-Recession cohorts and other cohorts facing the same demand conditions, which would appear in  $\delta_c$ . To avoid confounding the age and time effects with the experience of post-recession cohorts, who are observed only when young, in my preferred specifications I estimate (1) using data only on cohorts entering the market in 2000 and earlier, then hold the  $\beta_t$  and  $\gamma_a$  vectors fixed and extrapolate the  $\delta_c$ s for more recent birth cohorts. I obtain nearly identical results, however, when I simply estimate (1) on the entire sample.

The solid line in Figure 2 shows the cohort effects from the basic specification, applied to college graduates and extrapolated from the pre-recession sample. Figures A-4 and A-5 show the age and time effects, respectively, while Figure A-6 shows that cohort effects are nearly identical when the full sample is used to estimate (1). In Figure 2, cohort effects are largely stable, declining slightly but smoothly, for the entry cohorts between 1975 and 2004. The overall slope is determined by the normalization discussed above and not identified by the data, so the smooth decline could equally well be an increase. However, any change in the slope is identified. There is a sharp downward turn for cohorts entering after about 2005. The cumulative decline from the 2004 to the 2015 cohorts, relative to the slope between 1993 and 2004, is nearly five percentage points, with most of this decline occurring between 2006 and 2010. There are also smaller declines in cohort effects in earlier recessions.

There is little indication that the most recent cohorts have recovered any of the lost ground. Despite entering a labor market that was much stronger than that faced by the cohorts

entering in 2009-12, they continue to fare quite poorly relative to past cohorts observed at similar ages. By contrast, the pure time effects (Figure A-5) had fully recovered their 2007 levels by 2014. In other words, the model indicates that the slow recovery of college graduates' employment (shown as the solid line in Figure A-5) since 2011 is not evenly distributed, as might be expected if weak labor demand were the culprit, but is specific to younger cohorts. Older cohorts who were already established in the labor market by 2007 had fully recovered by 2013.

*B. Excess sensitivity and scarring*

In the context of the model specified by equation (1), the decline in cohort effects seen in Figure 2 indicates that post-recession cohorts will have lower employment rates in every year of their careers than pre-recession cohorts, after adjusting for any differences in time effects. In other words, the recession has a large, permanent scarring effect, totaling four to five percentage points, on the post-recession cohorts' annual employment rates.

However, equation (1) does not allow for two alternative explanations that would point to rosier futures. I explore these in turn. First, young people's employment is more cyclically sensitive than that of older people. Because the post-recession cohorts are observed only at young ages, and primarily at times when the unemployment rate is high, their estimated cohort effects may be depressed by the omission of age-unemployment interactions from (1).

To address this, I augment (1) with unemployment rate-age interactions. I create a sequence of age indicators  $g_j(a)$ ,  $j=1,\dots,5$ , where  $g_1(a)$  is an indicator for ages 22-23,  $g_2(a)$  for 24-25,  $g_3(a)$  for 26-27,  $g_4(a)$  for 28-29, and  $g_5(a)$  for 30-31. I then control for interactions between these indicators and  $UR_{st}$ :

$$Y_{satc} = \alpha + \beta_t + \gamma_a + \delta_c + \zeta_s + \rho\lambda(p_{atc}) + \sum_{j=1}^5 g_j(a) * UR_{st} * \theta_j + (UR_{st} - UR_t)\kappa + \epsilon_{satc}. \quad (2)$$

I also include a main effect for the deviation of the state unemployment rate from the national rate,  $(UR_{st} - UR_t)$ , to capture effects of local conditions on those aged 32 and over.<sup>5</sup>

The estimated  $\theta_j$ s are plotted, with confidence intervals, in Figure 3A. They show the expected excess sensitivity: Employment of the youngest college graduates falls by about 0.5 percentage point for every 1.0 percentage point increase in the unemployment rate, but the effect declines roughly linearly with age.

These estimates are based on the pre-recession cohorts, so generally on lower early-career unemployment rates than prevailed during the Great Recession. The dots in Figure 3A show estimates based on the full sample. These indicate somewhat more sensitivity, suggesting that the youngest graduates did even worse than expected during the Great Recession. But the extrapolation from pre-2007 patterns generally works well.

The short-dashed line in Figure 2 shows the estimated cohort effects from specification (2). The adjustment makes only a modest difference, with slightly better cohort effects for the 2001 to 2010 entry cohorts. It does nothing to improve the estimated cohort effects for the most recent entrants – not surprising, since the unemployment rate has not been elevated during most of their time in the market.

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<sup>5</sup> The  $\theta_j$  coefficients are interpreted as the effect of the state unemployment rate on those from age group  $j$ , relative to its effect on those over 32. Although the unemployment rate main effect is specified as the deviation of the state from the national rate, the time effects  $\beta_t$  capture any effect of the national unemployment rate on those aged 32 and older. Thus, my specification allows the national unemployment rate and the state deviation from that to have distinct main effects, but forces their age interactions to be the same.

Overall, this specification does not indicate that the apparent downturn in cohort effects in the base specification was an artifact of failing to allow for excess sensitivity of younger workers to economic conditions. The adjusted cohort effect series shows essentially the same decline between the pre- and post-recession cohorts as in the base specification.

A second explanation for the apparent decline in cohort effects is that the recession cohorts may have been scarred by their initial experiences, but that scarring effect will fade away as they gain experience. This would be consistent with many of the estimates in the scarring literature, which show effects that fade out over the first ten years of workers' careers. Because the post-recession cohorts are observed only at young ages, the estimated cohort effects from specification (1) will reflect the early-career impacts of elevated unemployment in 2007-2015, and may overstate the permanent damage to the post-recession cohorts.

Again, I address this by including terms in the decomposition that allow for gradual fade-out of the effects of entry conditions. The specification replaces the contemporaneous unemployment rate  $UR_{st}$  in (2) with the unemployment rate at labor market entry (i.e., at age 22),  $UR_{sc}$ :

$$Y_{satc} = \alpha + \beta_t + \gamma_a + \delta_c + \zeta_s + \rho\lambda(p_{atc}) + \sum_{j=1}^5 g_j(a) * UR22_{sc} * \varphi_j + (UR22_{sc} - UR22_c)\kappa + \epsilon_{satc}. \quad (3)$$

The  $\varphi_j$  coefficients represent age-cohort-state interactions.<sup>6</sup> Thus, this model has two ways that economic conditions in the first year of the career can have persistent effects: They

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<sup>6</sup> As before, I omit an interaction with the indicator for those aged 32 and above, and I include a main effect for the unemployment rate at cohort entry, deviated from the national rate in that year. This ensures that any permanent effects of the national unemployment rate at entry is captured by the  $\delta_c$  cohort effects, while allowing the deviation of the state from the national unemployment rate to have its own effect through  $\kappa$ .

can have medium-term consequences through the  $\varphi_j$  coefficients, and they can have permanent consequences via the cohort coefficients  $\delta_c$ .

Persistence is importantly different in (2) and (3). In (2), a transitory shock in  $t$  has effects on everyone in the first ten years of their careers (in addition to its overall effect), but none of these effects persist in  $t+1$ . In (3), only the newest entrants are affected, but these workers are damaged for as long as the next ten years. In the presence of serially correlated shocks, however, the two models are difficult to distinguish, as each predicts sustained poor outcomes for young workers.

Figure 3B shows the estimated  $\varphi_j$  coefficients from (3). We see strong effects of initial conditions on early career employment, fading out over about six years.<sup>7</sup> Again, these are slightly larger but basically similar when I include the post-recession cohorts in the sample as when I extrapolate from earlier cohorts, indicating that nonlinearity in the unemployment rate effect is not a major source of bias.

The cohort effects from this specification, plotted as long dashed lines in Figure 2, show a notably smaller decline – though still a quantitatively important one – in the period surrounding the Great Recession than in the two prior specifications. This indicates that the earlier failure to account for potential fade-out of the effects of the entry unemployment rate may have led me to overstate the sensitivity of permanent cohort effects with respect to entry conditions. In the adjusted series, there is still a sharp change in the series around the 2005 cohort, but the

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<sup>7</sup> It is possible that the later-age scarring coefficients are attenuated due to geographic mobility. My  $\varphi_j$  estimates are similar when, following von Wachter and Heisz (forthcoming), I instrument for URsc with a measure that abstracts from mobility. See the appendix.

subsequent decline is more gradual and linear. The decline from 2006-2010 is 60% as large as in the baseline specification. Declines in cohort effects during prior recessions are also attenuated.

### C. *Cyclicalities of estimated cohort effects*

The cohort effects plotted in Figure 2 appear strongly cyclical. To quantify this, Table 1 shows time series regressions of the three sets of cohort effects on the national unemployment rate when the cohort was 22, controlling for a quadratic time trend (which absorbs the normalization of the cohort effects). The sample for these regressions is the time series of estimated cohort effects for the entry cohorts of 1978 through 2017 (born in 1956 through 1995); standard errors allow for autocorrelation of the error terms at up to three lags.

Column 1 shows results for the initial decomposition, (1). Each 1 percentage point increase in the unemployment rate at the time of labor market entry is associated with a 0.22 percentage point permanent decline in the cohort employment rate. This is unchanged when the specification allows for excess sensitivity but declines to -0.11 and becomes insignificant when it allows for fadeout of early-career scarring effects. In other words, medium-term scarring effects account for about half of the cyclicalities of scarring effects from (1); the remainder are imprecisely estimated but still appear modestly cyclical. As I discuss below, the remaining response is quantitatively quite important.

Column 4 presents results from a specification that combines (2) and (3), allowing for both excess sensitivity and early-career scarring. In this specification, the  $\theta_j$  coefficients, capturing excess sensitivity, are similar to those seen in Figure 3A, but the  $\varphi_j$  coefficients are near zero. The cohort effects are as cyclical as in specification (1), even when both types of early-career effects are accounted for.



The lower rows of Table 1, Panel A, compare the estimated impact of the Great Recession to what the cyclical sensitivity model would predict, by comparing the change between the 2006 and 2010 entry cohorts, relative to that between the 2002 and 2006 cohorts, to the fitted values. The model captures the experience of the 2010 cohort reasonably well, though in column 3 the predicted decline is notably larger than the actual one.

*D. Earnings and wages*

I have also conducted parallel analyses of log annual earnings and for log hourly wages, in each case conditional on positive employment in the relevant period. Cohort effects are shown in Figures A-7 and A-8. Cohort effects on annual earnings decline notably for the 2007-12 entry cohorts, while the decline in hourly wages is confined to the 2009 entry cohort. I find stronger evidence for excess sensitivity and scarring for hourly wages than for annual earnings, though for each outcome allowing for scarring dramatically improves the estimated cohort effects for post-recession entrants. The lower panels of Table 1 show the association between each set of cohort effects and the entry unemployment rate. Wages but not earnings covary with unemployment at entry, though the relationship is only marginally statistically significant. Cyclicity of wages is notably reduced when I allow for early-career scarring (or for excess sensitivity). Both earnings and wages of the post Great Recession cohorts are notably better than would be predicted based on past cyclical patterns.

*E. Non-college workers*

Appendix Table A-1 shows parallel analyses for non-college workers, relating cohort effects on employment, wages, and earnings to the unemployment rate when they were 18 years

old. There is little indication of cyclicity of cohort effects on any outcome. There is modest evidence of medium-term scarring on non-graduates' employment, but little for wages or earnings (Appendix Figures A-9, A-10, and A-11). Cohorts that enter the market during recessions have lower wages and earnings for the first several years of their careers than do those entering at low-unemployment times (consistent with Schwandt and von Wachter, 2019), but in the long run their wages and earnings are if anything higher. This result has not been highlighted in earlier scarring studies, and calls for further investigation.

## **VI. Measuring the shadow cast by the Great Recession**

The results in Table 1 and Figure 2 indicate that recessions, and the Great Recession in particular, have hangover effects on college graduates' employment rates. About half of the cyclicity is accounted for by medium-term scarring, but a portion remains even after this is accounted for. This portion, because it is persistent, is by far the most important quantitatively. To illustrate this, I use the estimates from specification (3) to show the cumulative short-, medium-, and long-term effects of the Great Recession on college graduates' employment. This is conservative – any of the other specifications would assign larger roles to declines in cohort effects, and thus indicate larger long-term effects.

I simulate the future employment series under two scenarios. In both scenarios, I abstract from demographic considerations by assuming that all birth cohorts have the same number of college graduates, all graduates finish college by 22, and all retire at 65. In my first scenario, capturing the effects of the Great Recession, I use the estimated year effects  $\beta_t$  and cohort effects  $\delta_c$  from equation (3). To forecast the future, I assume that the 2015-2060 year effects revert to

their 2005-2007 average, while the cohort effects for cohorts entering after 2014 revert to their 2005-7 average. My second scenario is a counterfactual, representing a world in which the Great Recession did not happen. In this scenario, I use the empirical estimates only through 2007. Thereafter, I assume that year effects were constant from 2008 onward, at their 2005-2007 average, and that cohort effects were constant from the 2008 cohort onward, at their 2005-7 average. The assumed patterns are shown in Appendix Figure A-12.

The first panel of Figure 4 shows average employment rates of college graduates, age 22-65, under the two scenarios. They coincide through 2007, declining in the 2001 recession and then recovering. In scenario 1 (labeled “observed”), employment plummets in the Great Recession, then recovers about two-thirds of the loss. Beginning in 2015, it begins slowly trending downward. This reflects my assumption that future cohorts will resemble the ones that entered in 2005-2007. These cohorts have lower employment rates than earlier cohorts, so as the pre-2005 cohorts gradually retire the labor force average trends downward.

The second series shows the counterfactual scenario, with no Great Recession. We see the same gradual decline from 2015 onward as in scenario 1, but from a higher level. The two series move in parallel from 2015 through the mid-2050s, when the cohorts that entered following the Great Recession will retire, and then finally converge. Integrating the difference between them, we find a cumulative recession effect of 15.5 percentage point-years, of which only 7.9 percentage points occurred during the downturn years, 2.6 percentage points occurs between 2015 and 2025, and 5.0 percentage points will occur after 2025. The two latter portions represent the shadow of the recession, and are in combination nearly as large as the immediate effect.

There are three components to the recession effect indicated in panel A, reflecting the three time-varying terms in equation (3). These are shown separately in panels B, C, and D. Panel B shows the pure year effects  $\beta_t$ . These are the short-term direct effects of the recession, which are common to all participants in the labor market at the same time but do not persist after it ends. By construction, these are stable after 2014. The integrated gap between the two series here is 6.4: The recession caused the employment rate of college graduates to fall by 6.4 percentage point-years between 2008 and 2014.

Panel C shows the medium-term scarring effects, represented by the coefficients  $\phi_j$  in (3). These are specified to last beyond the initial shock for those cohorts that were exposed to it at labor market entry, but to fade out within ten years. To translate these into effects on the overall labor market at a point in time, I average  $\sum_j g_j(a) * UR_{sc} * \phi_j$  over all cohorts in the labor market in that year. These averages are graphed in Panel C. Because the scarring effects fade out quickly, the gap between the two scenarios, never large to begin with, nearly disappears by 2020. Cumulatively, scarring effects reduce employment by 1.8 percentage point-years, over one-quarter as large in total as the short-term effect. Over half of this occurred during the extended downturn itself, so the hangover after the shock is assumed to have ended cumulates to only 0.8 percentage point-years.

Panel D shows the long-run effects operating through the cohort coefficients  $\delta_c$ , averaged over all cohorts in the labor market at any point in time. They decline steadily in both scenarios over the entire period, due to the composition effect mentioned above. But there is a gap between the two scenarios over the duration of the careers of the 2008-2014 entry cohorts. The gap is small at any point in time, but it integrates to a total of 7.3: The permanent effects of the

recession on those who entered the labor market during it have a cumulative effect over a 40+ year period that is almost one-third larger than the short-term effect.<sup>8</sup>

DeLong and Summers (2012) define a hysteresis parameter  $\eta$ , representing the permanent decline in future output per unit cyclical reduction in current output. Summarizing the results from Figure 4, I estimate that the immediate effect of the Great Recession was to reduce employment of college graduates by 6.4 percentage point-years, and that this led to medium-term temporary scarring effects cumulating to 1.8 percentage point-years and long-term declines in cohort effects cumulating to 7.3 percentage point-years. Using a real discount rate of 2.5%, the medium- and long-term effects are equivalent in present value terms to a constant, permanent reduction in employment of 0.14 percentage points, or to  $\eta = 0.14/6.4 = 0.022$ .<sup>9</sup> This is at the low end of DeLong and Summers' (2012) posited range of  $0 \leq \eta \leq 0.2$ , though still large enough to be quantitatively important in their analysis. Moreover, this captures only a single, limited source of hysteresis: My specification does not capture any persistent effects of a recession on any workers who were already in the labor market when the recession began, such as those documented by Yagan (forthcoming), nor do I examine potential non-labor-side channels for hysteresis.

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<sup>8</sup> Because the downturn lasted for so long, 0.5 percentage point-years of the damage done by lower cohort effects occurred before it had ended.

<sup>9</sup> With higher discount rates of 5% or 10%, the permanent equivalents are 0.19 and 0.21 percentage point reductions per year, and  $\eta$  rises to 0.029 or 0.033, respectively.

## VII. Conclusion

The 2018 U.S. economy, having finally emerged from a decade-long slump, simultaneously exhibits historically low unemployment and an unimpressive employment-population ratio, particularly for young college graduates. If these outcomes reflect long-run consequences of the 2007-9 recession, it has important consequences for assessing the economic cost of cyclical volatility.

My analysis of college graduates' employment rates indicates that they are sensitive to the economic conditions that prevailed at the time that the graduates entered the labor market. Cohorts that graduate during recessions have lower employment rates even after the recession is past.

Past research has emphasized persistent but temporary hangover effects that evaporate within the first ten years after graduation. However, the experience of the cohorts that graduated college during and after the Great Recession has not been consistent with that: Their employment rates have recovered from the initial insult much more slowly than would be predicted based on these so-called scarring effects alone, given the extended period of low unemployment that we have experienced since 2015. My analysis highlights that cohort effects are a second channel by which early career weakness can have long-term effects. This channel, because it is so persistent, is by far the more quantitatively important.

If anything, the Great Recession cohorts are doing better than would be predicted based on the long-run relationship between entry conditions and cohort effects. However, even this better-than-expected performance implies an enormous hangover effect from the Recession that will persist for decades to come. It is concentrated on the employment margin, with some effect

as well on log annual earnings, and among college graduates. Although it will be many years before we can measure this effect conclusively, the evidence to date points to long-term effects of the recession on college graduates' employment that are notably larger than the short-term effect. This type of hysteresis is an important component of the impact cyclical variation in economic conditions. The imperative to minimize it constitutes a strong argument for counter-cyclical policies aimed at minimizing the initial shock.

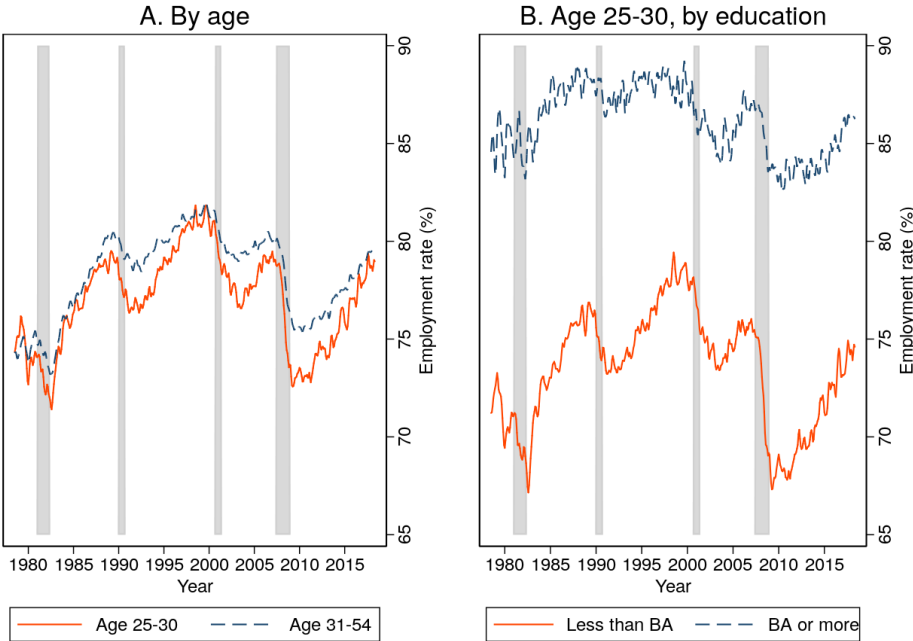
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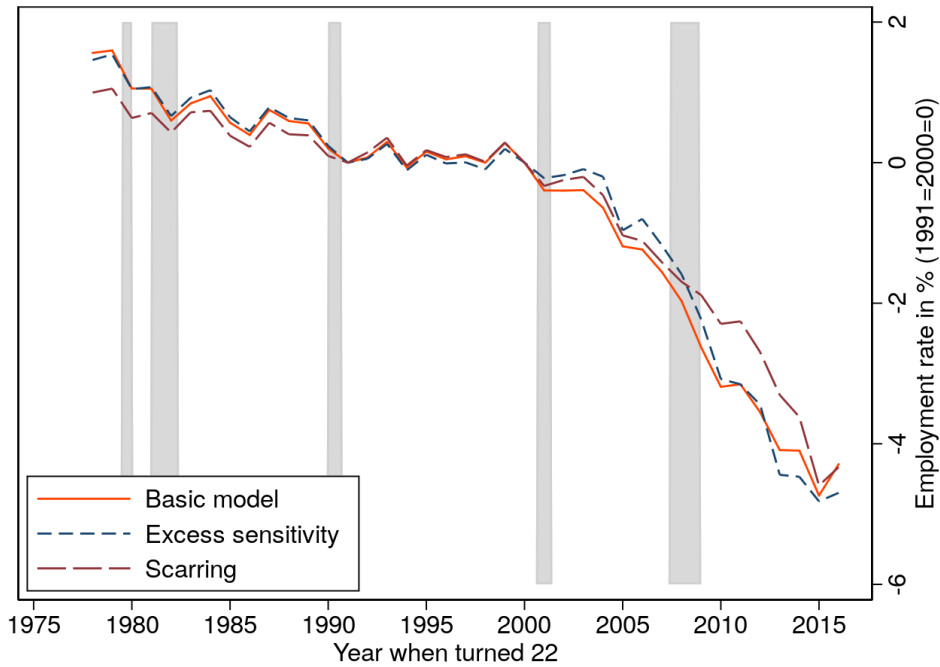
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Figure 1. Employment rates, by age and education, 1979-2018



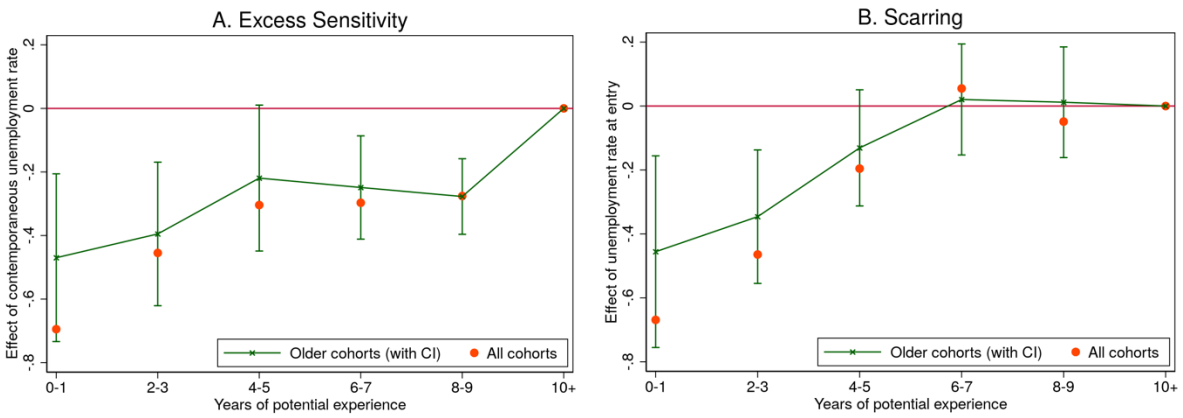
Notes: Prior week employment rates, computed from monthly Current Population Survey data, are seasonally adjusted and smoothed using a 3-month triangle smoother.

Figure 2. Cohort effects on employment rates of college graduates aged 22-40



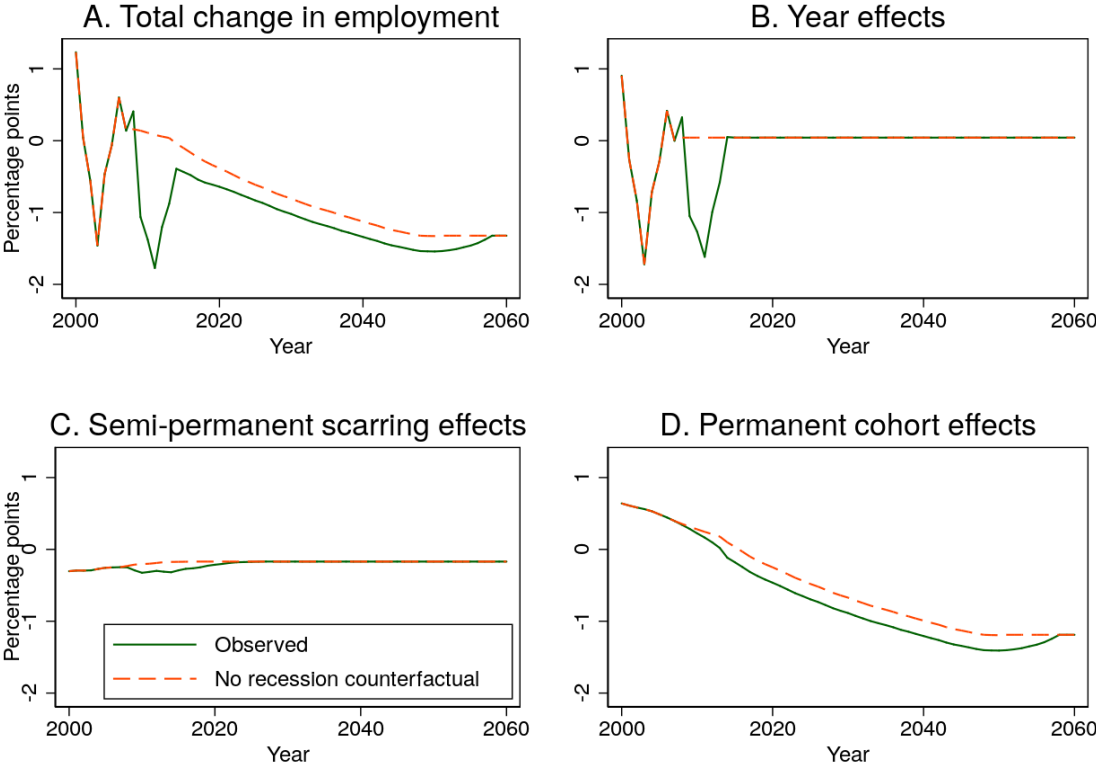
Notes: Prior-week employment rates are estimated from the monthly Current Population Survey and aggregated to the education-cohort-age-year-state cell. Specifications correspond to equations (1), (2), and (3), respectively, and include age, year, and state fixed effects, plus an inverse Mills ratio in the cohort-by-year college attainment rate. Cohorts are indexed by the year they turned 22; cohort effects are normalized to zero for the 1991 and 2000 entry cohorts. Regressions are estimated on a sample of college graduates age 22-40 from the 1970-2000 entry cohorts observed in 1978 to 2018. Cohort effects for post-2000 entrants are estimated assuming that age, time, and other coefficients are as estimated from the earlier cohorts.

Figure 3. Excess sensitivity and scarring coefficients from augmented age-time-cohort decompositions of college graduate employment rates



Notes: See notes to Figure 2. Panel A shows coefficients and confidence intervals for  $\theta_j$  coefficients, reflecting current unemployment rate-age interactions, from equation (2); panel B shows  $\varphi_j$  coefficients, reflecting entry unemployment rate-age interactions, from equation (3). Connected series and confidence interval correspond to estimates based on 1970-2000 entry cohorts, while dots correspond to estimates using all entry cohorts through 2017.

Figure 4. Decomposition of the long-run effect of the Great Recession on the employment rate of college graduates



Notes: See text for details. Estimates are based on the specification plotted in Figures 2 (“scarring” series), 3B, and Appendix Figures 6 and 7.

Table 1. Time series regressions of estimated cohort effects on the national unemployment rate in the year the cohort entered the labor market

	(1)	(2)	(3)	(4)
<b>Panel A: Employment</b>				
Unemployment rate at age 22	-0.22 (0.05)	-0.22 (0.05)	-0.11 (0.07)	-0.23 (0.04)
Cohort effect model controls for				
Excess sensitivity		Y		Y
Semi-permanent scarring			Y	Y
Change between 2006 and 2010 entry cohorts, vs. 2002 to 2006				
Predicted	-1.4	-1.4	-0.7	-1.4
Actual	-1.1	-1.7	-0.3	-1.6
<b>Panel B: Mean log annual earnings</b>				
Unemployment rate at age 22 (*100)	-0.04 (0.24)	0.02 (0.22)	0.26 (0.20)	0.25 (0.20)
Change between 2006 and 2010 entry cohorts, vs. 2002 to 2006				
Predicted	-0.3	0.1	1.6	1.5
Actual	5.1	5.3	3.5	5.4
<b>Panel C: Mean log hourly wages</b>				
Unemployment rate at age 22 (*100)	-0.74 (0.35)	-0.13 (0.23)	-0.42 (0.23)	-0.56 (0.25)
Change between 2006 and 2010 entry cohorts, vs. 2002 to 2006				
Predicted	-4.6	-0.8	-2.6	-3.5
Actual	1.9	1.6	2.1	1.4

Notes: Each entry corresponds to a separate regression of estimated cohort effects for college graduates on the unemployment rate in the year the cohort was 22, with a quadratic calendar year control and Newey-West standard errors allowing for autocorrelations at lags up to three years. Cohort effects in columns 1-3 are estimated using equations (1), (2), and (3), respectively. In column 4, the specification combines (2) and (3), with controls for both URst -age and URsc -age interactions. Lower rows show estimates for cohort effects on log hourly wages among those employed, from the CPS Outgoing Rotation Groups, and on log annual earnings among those with positive annual employment, from the March CPS. The bottom rows of each panel show the difference between the fitted or actual value for the 2010 and 2006 entry cohorts, less the difference between the 2006 and 2002 cohorts.

## Appendices

### Appendix A. Data processing and definitions

The primary analysis concerns the cohort-age-year-state employment rate for college graduates. This is estimated from the monthly Current Population Survey (CPS). I construct a synthetic panel from data from each month from January 1979 through November 2018, aggregating to each calendar year.

I divide the population into college graduates and non-graduates. Before 1992, graduates are those with 16 or more years of completed schooling; afterward, it is those with Bachelors or graduate degrees. Individual respondents are assigned the age (and implied birth cohort) that they are on the survey date, so someone born on July 1, 1980 and surveyed in 2010 will be treated as age 29 in 2010 and born in 1981, if surveyed in the first half of the calendar year, and as 30 and born in 1980 if surveyed in the second half.

My full sample for age-time-cohort decompositions (equations 1-3) consists of people born 1948-1995 (who turned 22 between 1970 and 2017) and observed at ages 22-40. As discussed in the text, my primary estimates identify the age, time, and auxiliary control coefficients only from pre-Recession cohorts. For these specifications, I exclude post-1978 birth cohorts, who turned 22 after 2000. I use the resulting coefficients to form predictions for the subsequent cohorts, and estimate their cohort effects as the difference between observed outcomes and the predictions.

When I examine non-high-school graduates, the sample extends from age 18-40, and begins with the 1952 birth cohort. The full sample extends to the 1999 birth cohort, while the pre-Recession sample again excludes those born after 1978.

In specification (2), I control for the contemporaneous unemployment rate. This is the state average unemployment rate for the calendar year. Specification (3) controls for the unemployment rate when the cohort was 22 years old (18 for non-college-graduates). I use the state where the respondent currently lives for this. State unemployment rates are not available prior to 1976; for the 1948-1954 (or, for non-graduates, 1952-1958) birth cohorts, I use the national unemployment rate.

All analyses are weighted by the sum of CPS sample weights in the cell.

I also present results for log annual earnings and log hourly wages. For annual earnings, I use the 1979-2018 Annual Social and Economic Supplement (ASEC), also known as the March CPS. Each ASEC survey includes information about earnings during the prior calendar year. I measure education and age as of the survey date, but use the prior calendar year's unemployment rate. Earnings are topcoded at the 98<sup>th</sup> percentile, separately by year; converted to real 2015 dollars using the CPI; and logged. Hourly wages are computed from the 1979-2017 Merged Outgoing Rotation Group (ORG) files from the monthly CPS, using an algorithm adapted from Center for

Economic and Policy Research (2018; see also Schmitt 2003). I use the higher of the reported hourly wage (without overtime, tips, or commissions), for those paid hourly, and the ratio of weekly earnings (which in principle include overtime, tips, and commissions) to usual weekly hours. When necessary, usual hours are imputed using actual hours last week or the mean by gender and part time status. Hourly wages are again converted to real 2015 dollars, set to missing if below \$1 or above \$200, and logged.

## **Appendix B. Additional specifications**

I present a range of additional specifications and models in the appendix. I discuss them in turn.

### Educational attainment

I rely on educational attainment as of the CPS survey date. Some people interviewed at age 22 who do not have college degrees at that time will obtain them later. This means that the composition of my college graduate sample changes across age within cohorts. Figure A-3 shows mean attainment by cohort and year. I group entry cohorts into two-year groups. For example, the “1980” series includes those who were 22 in 1980 and 1981. I then show the average attainment of each cohort group in each year until the group is 29/30. Dots indicate the observations when the cohort is 23/24 and when it is 29/30.

For the 1980-1989 entry cohorts, educational attainment was largely stable. Beginning with the 1990 entry cohort, age-30 attainment rose sharply, by about 5 percentage points, with nearly all of this growth occurring among degrees awarded after age 24. Attainment grew slowly from the 1990 to the 2010 entry cohorts, with growth mostly among degrees awarded before 24; between 2002 and 2010, there was even growth in pre-22 awards. Post-2010 entrants are not observed through age 30. There is some indication that post-24 degree awards have risen for these cohorts, but we will not know for sure until their education is complete.

### Main decompositions

Figures A-4 and A-5 show estimated age and time effects, respectively, from the main decomposition (1) for employment of college graduates. These are estimated on the pre-Great-Recession cohorts, turning 22 from 1970 through 2000. For comparison, Figure A-4 shows estimated age effects from a specification that includes calendar year but not cohort controls. Age effects are normalized to zero at age 32. The comparison series in Figure A-5 is the unadjusted average employment rate of 22-40-year-old college graduates in each year, without adjustment for cohort differences. Here, year effects are normalized to zero in 2007. In each figure, the cohort effects in the full decomposition are normalized to have zero slope between the 1991 and 2000 entry cohorts.

Figure A-6 shows two sets of estimates of cohort effects from equations (1) and (3). One set, in dashed lines, uses the pre-recession cohorts to identify age, time, and scarring coefficients, then extrapolates these coefficients to subsequent cohorts. The other uses the full sample to estimate the regressions. Results are generally similar.



Figures A-7 and A-8 repeat the decompositions in Figures 2 and 3 of the main text, first for log annual earnings and then for log hourly wages. Samples here exclude those with zero work in the prior year (A-7) or prior week (A-8).

Figures A-9 through A-11 present decompositions for non-college graduates. These are similar to college graduates, except that cohorts enter the sample at age 18, the age-18 unemployment rate is the relevant entry condition, the  $g_j(a)$  coefficients refer to years since age 18, and the selection control is an inverse Mills ratio in the share of the cohort that *did not* graduate from college,  $\lambda(1 - p_{atc})$ . Estimates of the cyclicity of the cohort effect estimates, with respect to the age-18 unemployment rate, are in Table A-1.

### Simulation of the effect of the Great Recession

Figure A-12 presents the assumed time and cohort effects used in the simulation of the long-term effects of the Great Recession, Figure 4.

### Sensitivity to mobility

In equation (3), I use the unemployment rate when the individual was 22, in the state of current residence, as a measure of labor market conditions when that individual entered the market. Interstate mobility between age 22 and the date of the CPS interview will make this a noisy measure of initial conditions. Further, any endogeneity of this mobility to local conditions could bias my results.

To address this, I use an instrumental variables strategy adapted from Schwandt and von Wachter (2019).<sup>1</sup> Construction of the instrument has three steps.

First, using pooled data from the 1980, 1990, and 2000 decennial census and from the 2001-2016 American Community Survey (one-year samples) public use microdata files, I estimate the number of college graduates born in each state  $b$  living in state  $s$  at age  $a$  ( $22 \leq a \leq 40$ ),  $N_{bsa}$ . This is a long-run average, pooled across nearly forty years of data, so is not influenced by economic conditions relevant for any single cohort.

Second, I construct the average age-22 unemployment rate to which college graduates born in each state  $b$  and each birth cohort  $c$  would have been exposed. Let  $t=c+22$ . This average rate is then:

$$\widehat{UR22}_{bc} = \frac{\sum_s UR22_{st} N_{bs,22}}{\sum_s N_{bs,22}}.$$

Third, for each state  $s$ , cohort  $c$ , and age  $a$ , I average the average birth-state exposure across all birth states, weighting by the share of age- $a$  graduates in state  $s$  born in each state  $b$ :

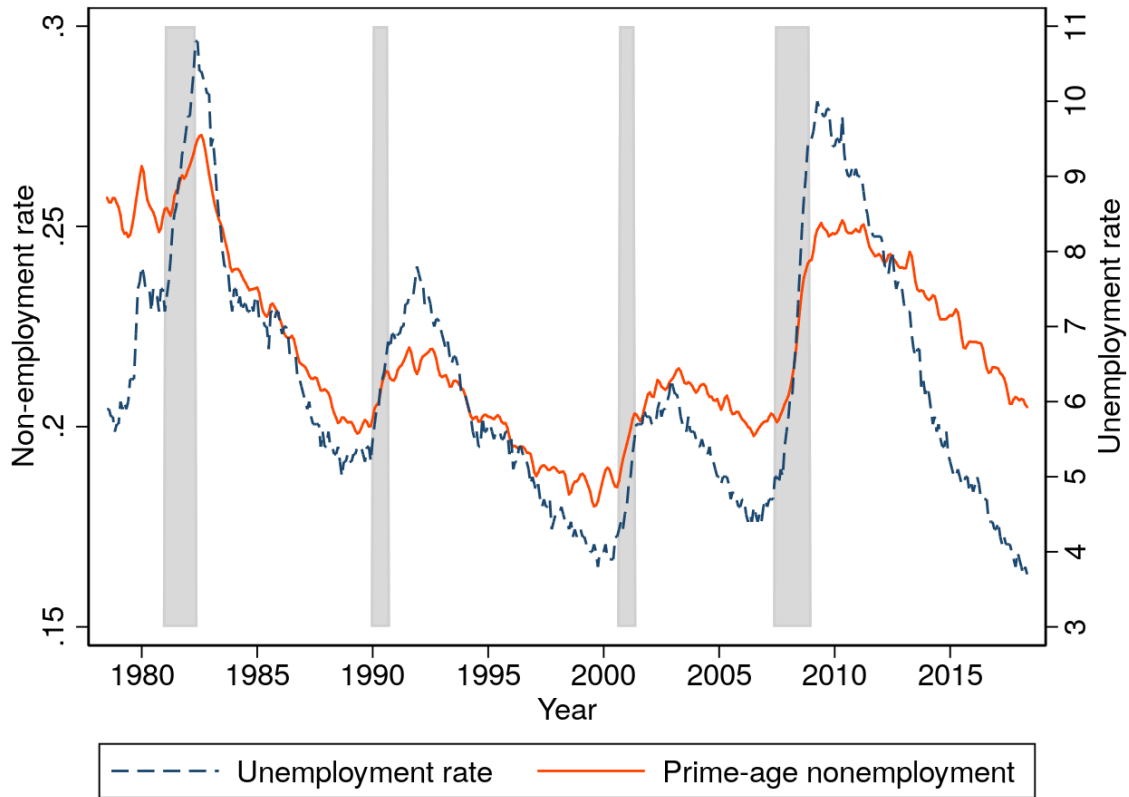
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<sup>1</sup> Schwandt and von Wachter (2019) use a double-weighting estimator to abstract from both endogenous mobility and endogenous attainment rates. I treat attainment rates as exogenous, using the selection correction discussed in the text to address changes in cohort composition with age.

$$\overline{UR22}_{sca} = \frac{\sum_b \overline{UR22}_{bc} N_{bsa}}{\sum_b N_{bsa}}.$$

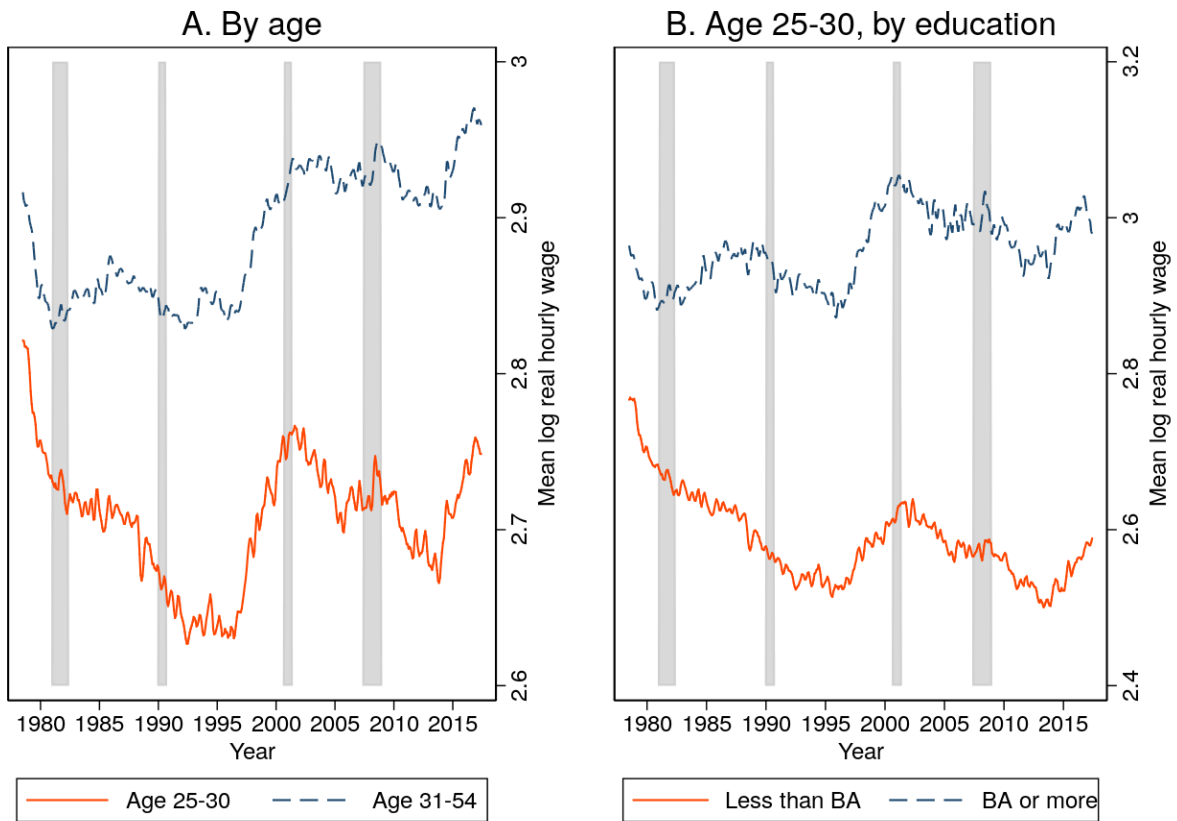
Last, I interact this measure with age indicators  $g_j(a)$  ( $j=1, \dots, 5$ ) and use the results as instruments for the  $g_j(a) * UR22_{sc}$  interactions in equation (3). Appendix Table A-2 shows the estimated scarring coefficients from the base OLS specification and using IV, both using the full sample and limiting to the pre-recession entrants. Coefficients are similar, and if anything smaller in the IV specifications. In other words, accounting for endogenous mobility attributes *more* of the post-Great-Recession decline in young people's outcomes to permanent cohort effects than in my main results.

Appendix Figure A-1. Unemployment rate and prime-age non-employment rate



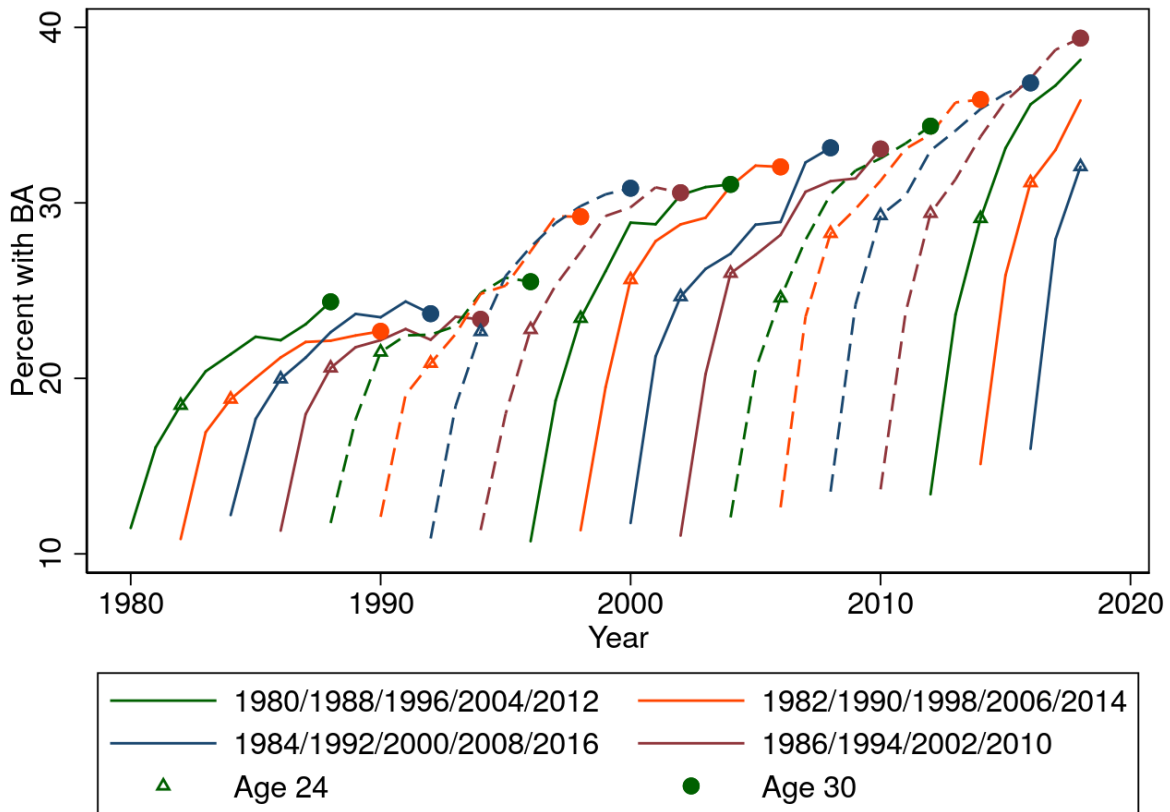
Notes: Unemployment rate is the published, seasonally adjusted rate. Non-employment rate is calculated over 25-54 year olds from the CPS microdata samples, and does not exactly match the published estimates. It is seasonally adjusted and smoothed using a three-period triangle smoother.

Appendix Figure A-2. Mean log real hourly wages, by age and education, 1979-2018



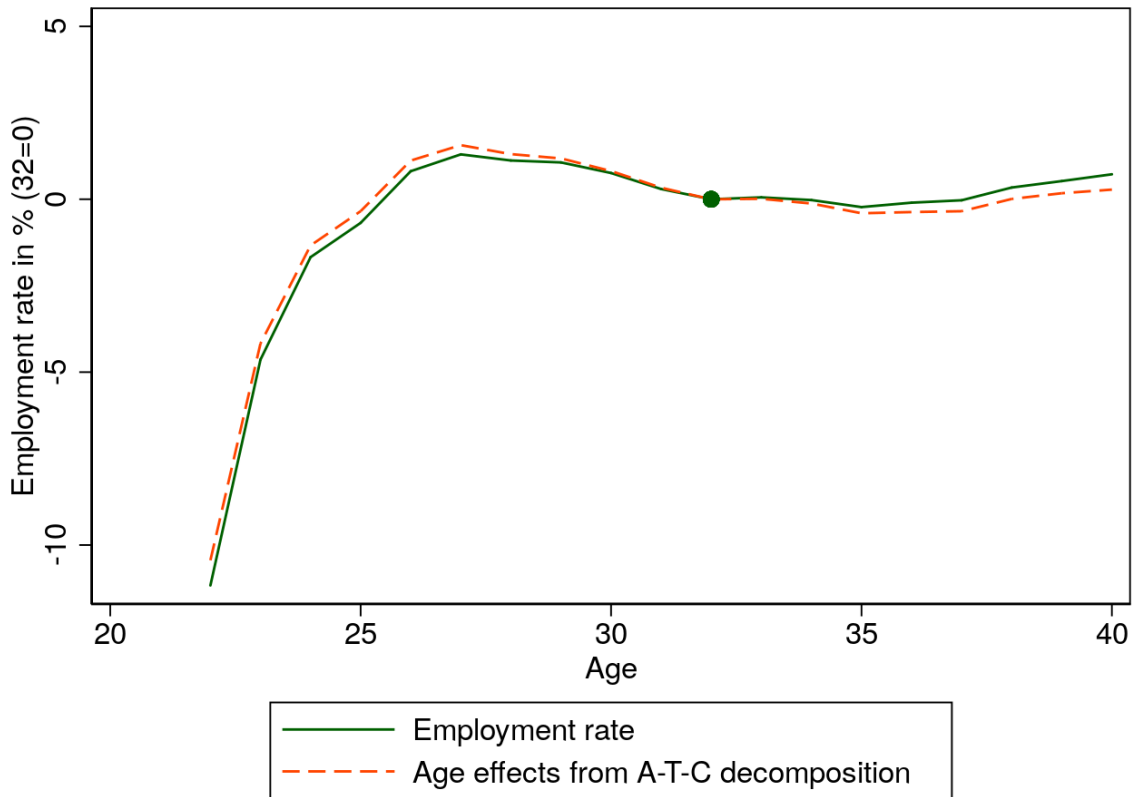
Notes: Hourly wages are censored at real values of \$1 and \$200 per hour (in 2015 dollars). Annual averages are smoothed with a 5-month triangle smoother.

Appendix Figure A-3. Share of cohort with a bachelor's degree, by cohort and year



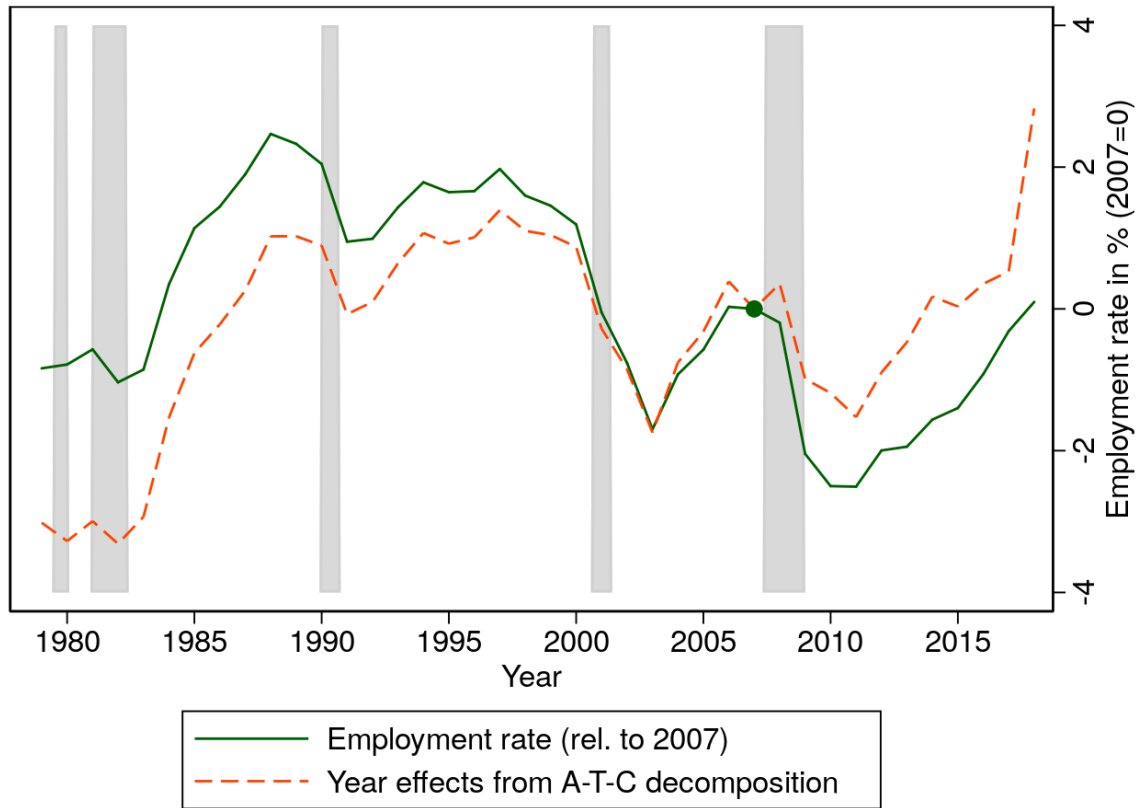
Notes: Each series represents two adjacent birth cohorts, tracked from 22 through 30. For example, the first series includes those who were 22 in 1980 and 1981. Legend shows the year in which the first cohort in each pair was 22. Triangles and dots indicate observations when respondents were 24 and 30 years old, respectively.

Appendix Figure A-4. Age effects on employment of college graduates



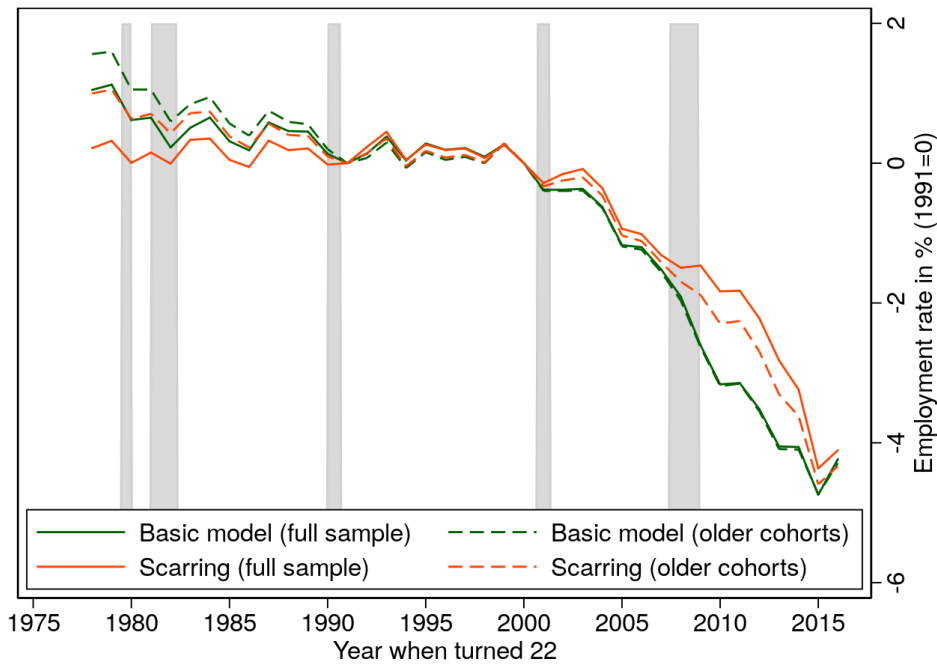
Notes: “Employment rate” series represents estimated cohort-adjusted age effects on employment from a restricted version of equation (1) with no calendar year effects, estimated on college graduates aged 22-40 from the 1970-2000 entry cohorts observed 1979-2018. “Age effects” series is drawn from equation (1), estimated on the same sample and including calendar year adjustments. Age effects are normalized to zero at age 32 (indicated by a dot); the full age-time-cohort decomposition further normalizes the cohort effects to be the same for the 1991 and 2000 entry cohorts.

Appendix Figure A-5. Time effects on employment of college graduates



Notes: “Employment rate” series is the unadjusted average employment rate of 22-40-year-old college graduates in each year, relative to 2007. “Year effects” series is drawn from equation (1), estimated on college graduates aged 22-40 from the 1970-2000 entry cohorts observed 1979-2018 and including calendar year and age adjustments. Year effects are normalized to zero in 2007; the full age-time-cohort decomposition further normalizes the cohort effects to be the same for the 1991 and 2000 entry cohorts.

Appendix Figure A-6. Cohort effects on employment: Extrapolated from pre-recession cohorts and estimated using the full sample

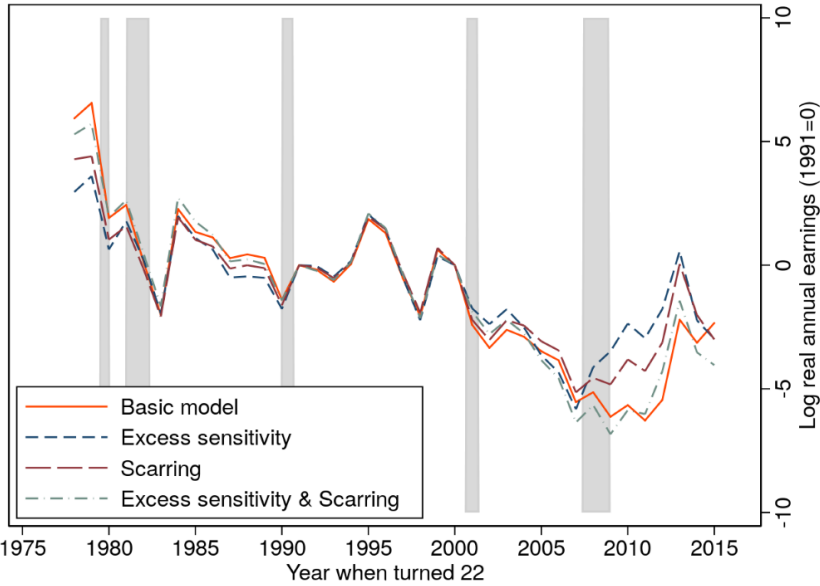


Notes: Figure presents estimated cohort effects from equations (1) and (3). Solid lines show effects estimated using the full sample. Dashed lines show series obtained by estimating the age-time-cohort decomposition using only cohorts aged 22 by 2000, then estimating post-2000 cohort effects as mean residuals by cohort after subtracting time and age effects estimated from the earlier data. In each case, cohort effects are normalized to zero for the 1991 and 2000 entry cohorts.

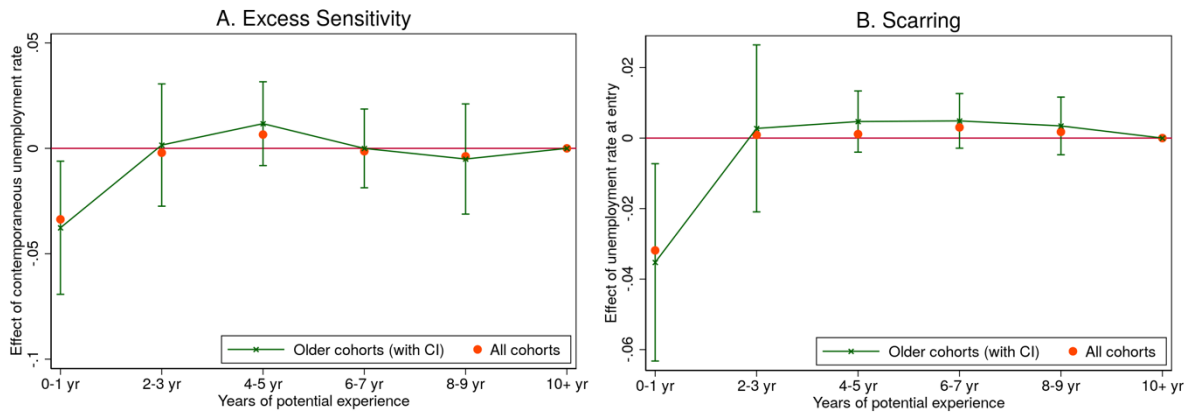


Appendix Figure A-7. Cohort effects, excess sensitivity, and scarring for college graduates' log annual earnings if employed

A. Cohort effects on log annual earnings of college graduates



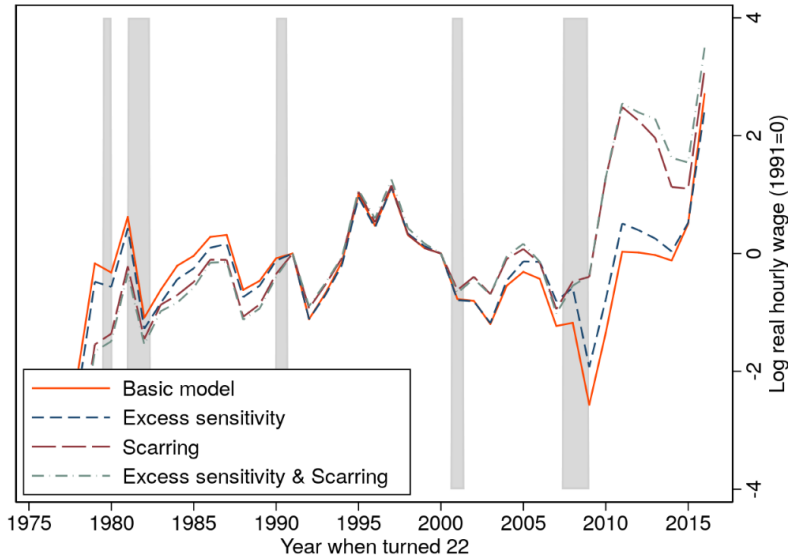
B. Excess sensitivity and scarring effects on log annual earnings



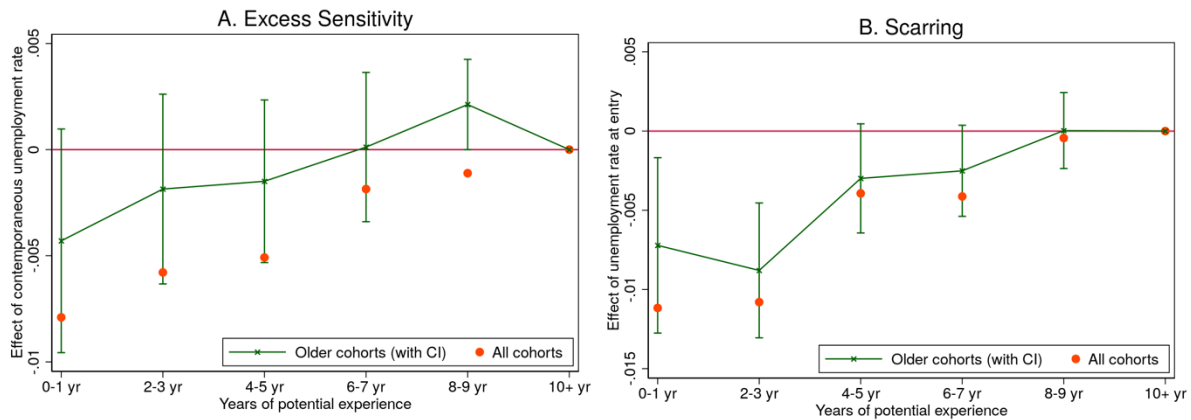
Notes: Annual earnings are computed from March CPS data, for those with positive earnings, then logged and averaged to the education-cohort-age-year-state cell. Specifications correspond to equations (1), (2), and (3), respectively, and include age, year, and state fixed effects, plus an inverse Mills ratio in the cohort-by-year college attainment rate. Cohorts are indexed by the year they turned 22; cohort effects are normalized to zero for the 1991 and 2000 entry cohorts. Decompositions are estimated on college graduates aged 22-40 from the 1970-2000 entry cohorts observed 1979-2018, then extrapolated to the post-2000 entry cohorts holding all but cohort effects fixed.

Appendix Figure A-8. Cohort effects, excess sensitivity, and scarring for college graduates' log hourly wages if employed

A. Cohort effects on log hourly wages of college graduates



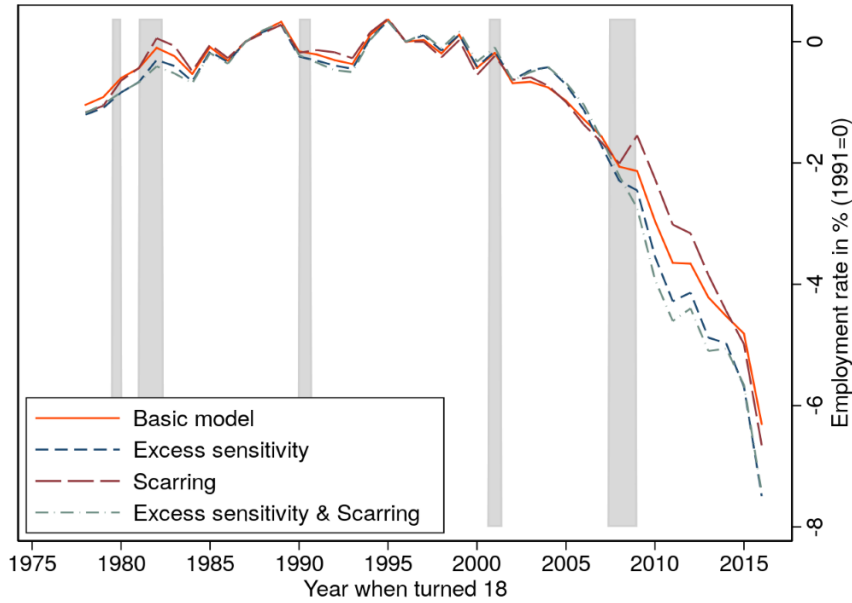
B. Excess sensitivity and scarring effects on log hourly wages



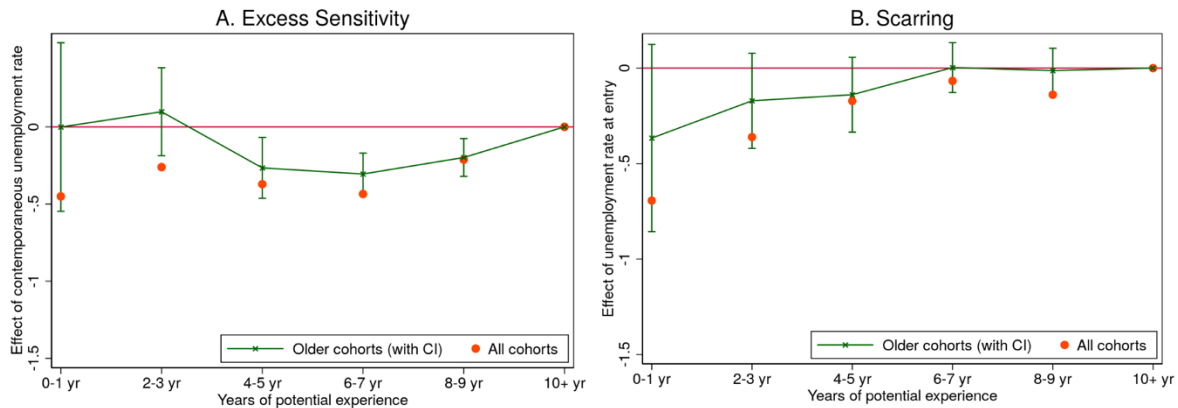
Notes: Hourly wages are computed from the Merged Outgoing Rotation Groups, for those with positive prior-year earnings, then logged and averaged to the education-cohort-age-year-state cell. Specifications correspond to equations (1), (2), and (3), respectively, and include age, year, and state fixed effects, plus an inverse Mills ratio in the cohort-by-year college attainment rate. Cohorts are indexed by the year they turned 22; cohort effects are normalized to zero for the 1991 and 2000 entry cohorts. Decompositions are estimated on college graduates aged 22-40 from the 1970-2000 entry cohorts observed 1979-2018, then extrapolated to the post-2000 entry cohorts holding all but cohort effects fixed.

Appendix Figure A-9. Cohort effects, excess sensitivity, and scarring for non-graduates' employment

A. Cohort effects on employment rates of non-college graduates



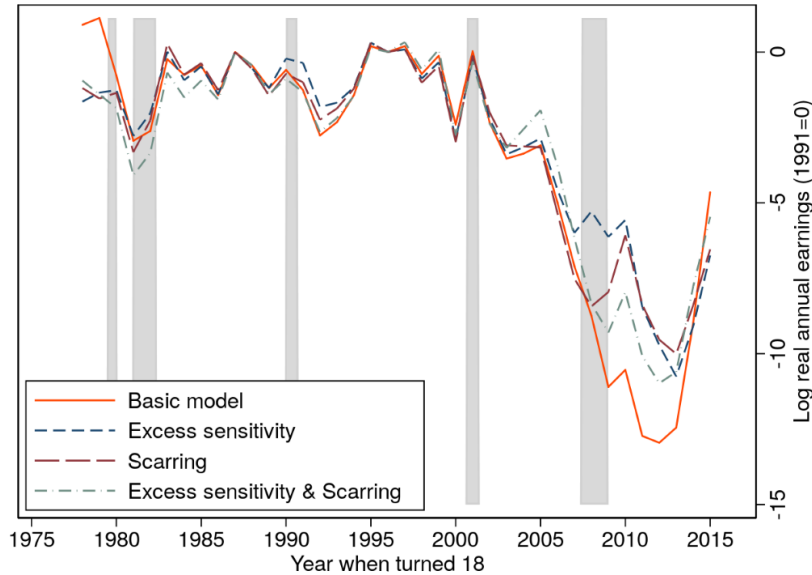
B. Excess sensitivity and scarring effects on employment of non-college graduates



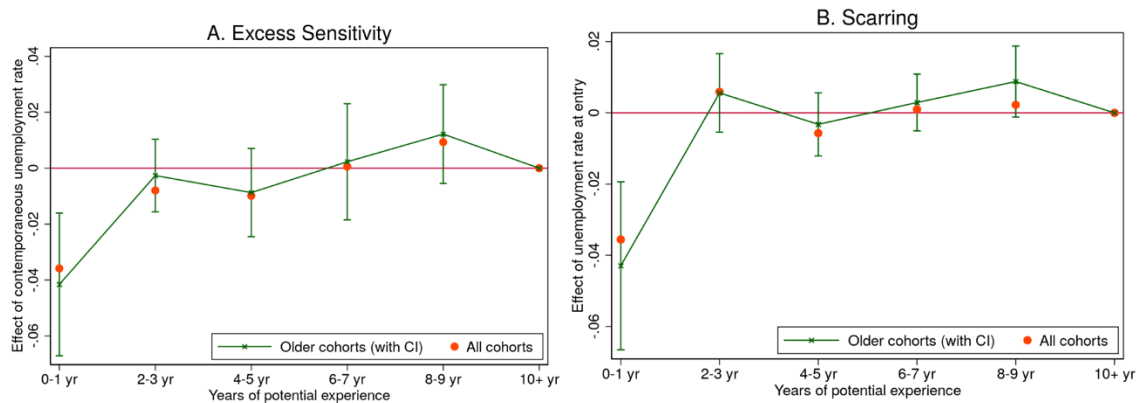
Notes: Prior-week employment rates are estimated from the monthly Current Population Survey and aggregated to the education-cohort-age-year-state cell. Specifications correspond to equations (1), (2), and (3), respectively, and include age, year, and state fixed effects, plus an inverse Mills ratio in the cohort-by-year college non-attainment rate. Cohorts are indexed by the year they turned 18; cohort effects are normalized to zero for the 1991 and 2000 entry cohorts. Regressions are estimated on a sample of non-college graduates age 18-40 from the 1970-1996 entry cohorts observed in 1978 to 2018. Cohort effects for post-1996 entrants are estimated assuming that age, time, and other coefficients are as estimated from the earlier cohorts.

Appendix Figure A-10. Cohort effects, excess sensitivity, and scarring for non-graduates' log annual earnings if employed

A. Cohort effects on log annual earnings of non-college graduates



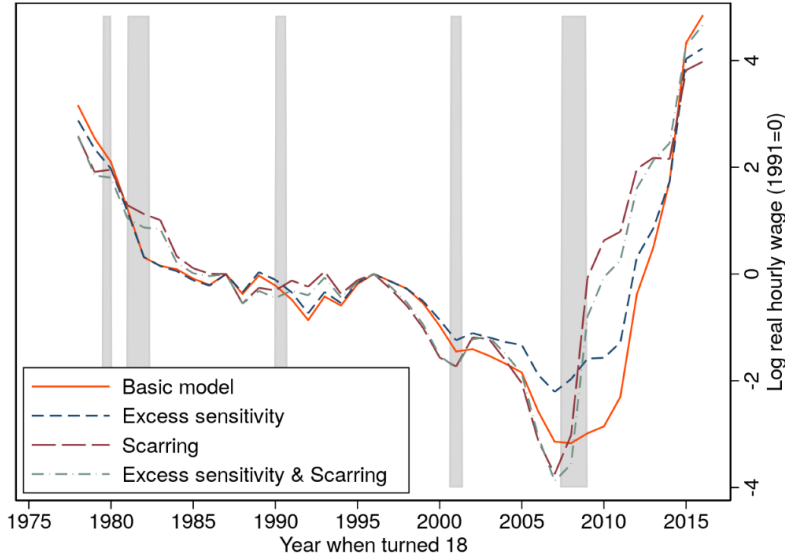
B. Excess sensitivity and scarring effects on log annual earnings of non-college graduates



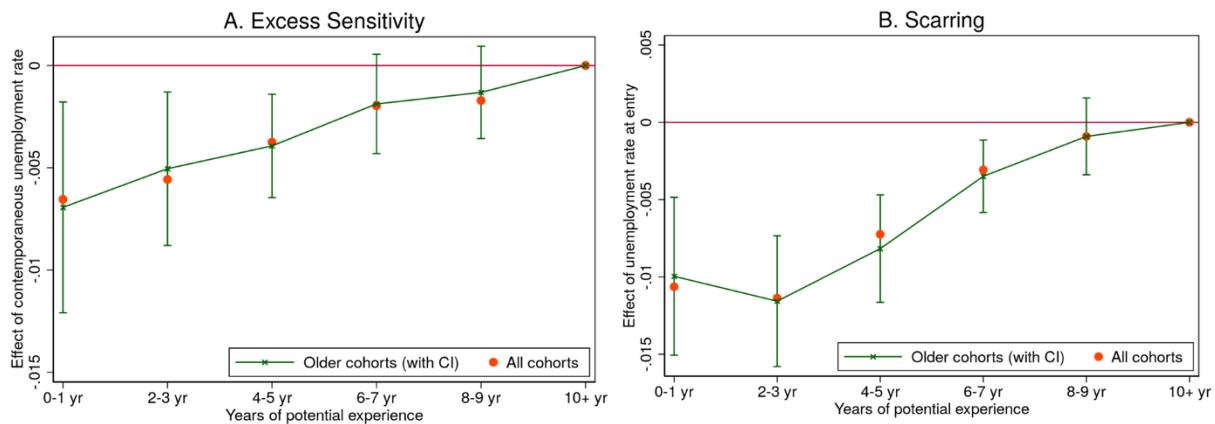
Notes: Annual earnings are computed from March CPS data, for those with positive earnings, then logged and averaged to the education-cohort-age-year-state cell. Specifications correspond to equations (1), (2), and (3), respectively, and include age, year, and state fixed effects, plus an inverse Mills ratio in the cohort-by-year college non-attainment rate. Cohorts are indexed by the year they turned 18; cohort effects are normalized to zero for the 1991 and 2000 entry cohorts. Regressions are estimated on a sample of non-college graduates age 18-40 from the 1970-1996 entry cohorts observed in 1978 to 2018. Cohort effects for post-1996 entrants are estimated assuming that age, time, and other coefficients are as estimated from the earlier cohorts.

Appendix Figure A-11. Cohort effects, excess sensitivity, and scarring for non-graduates' log hourly wages if employed

A. Cohort effects on log hourly wages of non-college graduates

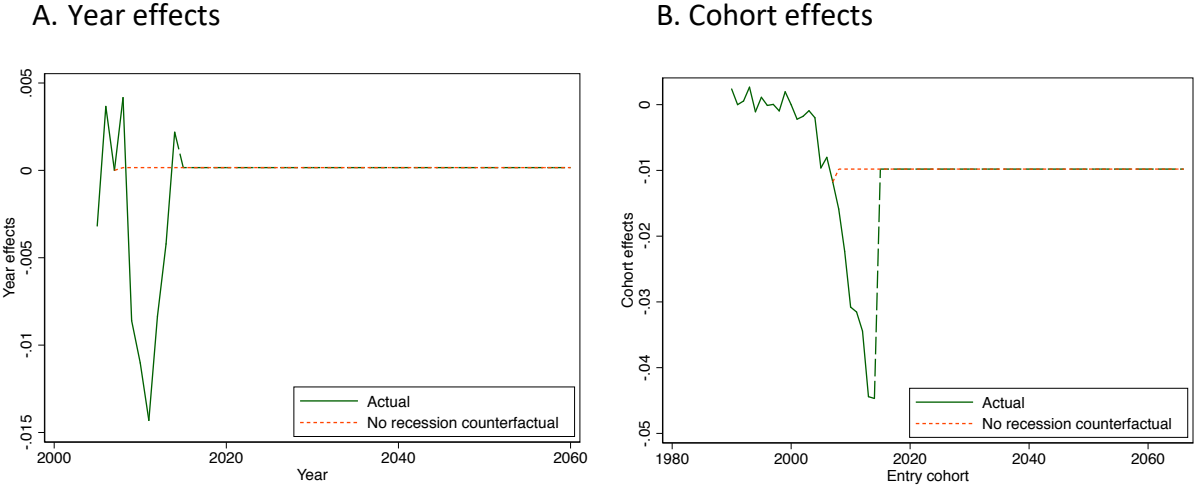


B. Excess sensitivity and scarring effects on log hourly wages of non-college graduates



Notes: Hourly wages are computed from the Merged Outgoing Rotation Groups, for those with positive prior-year earnings, then logged and averaged to the education-cohort-age-year-state cell. Specifications correspond to equations (1), (2), and (3), respectively, and include age, year, and state fixed effects, plus an inverse Mills ratio in the cohort-by-year college non-attainment rate. Cohorts are indexed by the year they turned 18; cohort effects are normalized to zero for the 1991 and 2000 entry cohorts. Regressions are estimated on a sample of non-college graduates age 18-40 from the 1970-1996 entry cohorts observed in 1978 to 2018. Cohort effects for post-1996 entrants are estimated assuming that age, time, and other coefficients are as estimated from the earlier cohorts.

Appendix Figure A-12. Assumed time and cohort effects for simulation of the long-term effects of the Great Recession



Notes: “Actual” series is estimated year (panel A) and cohort (panel B) effects from the “scarring” specification plotted in Figure 2 (equation 3), through 2014. The series then revert to their averages in 2005-7. The “no recession counterfactual” series equals the actual series through 2007, then equal the 2005-7 average thereafter.

Appendix Table A-1. Time series regressions of estimated cohort effects for non-graduates on the national unemployment rate in the year the cohort was 18

	(1)	(2)	(3)	(4)
<b>Panel A: Employment</b>				
Unemployment rate at entry	-0.03 (0.04)	-0.08 (0.05)	0.11 (0.07)	-0.11 (0.06)
Cohort effect model controls for				
Excess sensitivity		Y		Y
Semi-permanent scarring			Y	Y
Change between 2006 and 2010 entry cohorts, vs. 2002 to 2006				
Predicted	-0.2	-0.5	0.7	-0.7
Actual	-0.1	0.0	-0.4	0.1
<b>Panel B: Mean log annual earnings</b>				
Unemployment rate at entry (*100)	-0.06 (0.25)	0.05 (0.21)	0.22 (0.16)	0.10 (0.18)
Change between 2006 and 2010 entry cohorts, vs. 2002 to 2006				
Predicted	-0.4	0.3	1.3	0.6
Actual	1.9	1.6	2.1	1.4
<b>Panel C: Mean log hourly wages</b>				
Unemployment rate at entry (*100)	0.17 (0.73)	0.76 (0.50)	0.06 (0.39)	-0.34 (0.46)
Change between 2006 and 2010 entry cohorts, vs. 2002 to 2006				
Predicted	1.1	4.7	0.4	-2.1
Actual	-3.2	-3.1	-2.3	-3.1

Notes: Each entry corresponds to a separate regression of estimated cohort effects for non-graduates on the unemployment rate in the year the cohort was 18, with a quadratic calendar year control and Newey-West standard errors allowing for autocorrelations at lags up to three years. Cohort effects in columns 1-3 are estimated using equations (1), (2), and (3), respectively. In column 4, the specification combines (2) and (3), with controls for both URst -age and URsc -age interactions. Lower rows show estimates for cohort effects on log hourly wages among those employed, from the CPS Outgoing Rotation Groups, and on log annual earnings among those with positive annual employment, from the March CPS. The bottom rows of each panel show the difference between the fitted or actual value for the 2010 and 2006 entry cohorts, less the difference between the 2006 and 2002 cohorts.

Appendix Table A-2. Instrumenting for the age-22 unemployment rate

	Pre-Great Recession cohorts		All cohorts	
	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)
Coefficient on interaction of age-22 unemployment rate with indicator for age:				
22-23	-0.52 (0.14)	-0.30 (0.13)	-0.72 (0.15)	-0.56 (0.14)
24-25	-0.43 (0.11)	-0.28 (0.10)	-0.52 (0.10)	-0.41 (0.09)
26-27	-0.20 (0.09)	-0.14 (0.08)	-0.24 (0.09)	-0.20 (0.08)
28-29	0.00 (0.09)	-0.01 (0.09)	0.04 (0.06)	0.05 (0.06)
30-31	-0.04 (0.09)	-0.08 (0.09)	-0.08 (0.07)	-0.12 (0.08)

Notes: Columns 1 and 3 correspond to the scarring estimates from Figure A-6. Columns 2 and 4 repeat the same specifications, instrumenting for the age-22 unemployment rate-age interactions with a simulated unemployment rate (again interacted with age) that abstracts from cohort-specific mobility. See text for details.