Sources of Displaced Workers' Long-Term Earnings Losses[1]

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Abstract

We estimate the earnings losses of a cohort of workers displaced during the Great Recession and decompose those long-term losses into components attributable to fewer work hours and to reduced hourly wage rates. We also examine the extent to which the reduced earnings, work hours, and wages of these displaced workers can be attributed to factors specific to pre- and post-displacement employers; that is, to employer-specific fixed effects. The analysis is based on employer-employee linked panel data from Washington State assembled from 2002–2014 administrative wage and unemployment insurance (UI) records.

Three main findings emerge from the empirical work. First, five years after job loss, the earnings of these displaced workers were 16 percent less than those of comparison groups of non-displaced workers. Second, earnings losses within a year of displacement can be explained almost entirely by lost work hours; however, five years after displacement, the relative earnings deficit of displaced workers can be attributed roughly 40 percent to reduced hourly wages and 60 percent to reduced work hours. Third, for the average displaced worker, lost employer-specific premiums account for about 11 percent of long-term earnings losses and nearly 25 percent of lower long-term hourly wages. For workers displaced from employers paying top-quintile earnings premiums (about 60 percent of the displaced workers in the sample), lost employer-specific premiums account for more than half of long-term earnings losses and 83 percent of lower long-term hourly wages.

JEL classifications: C21, J22, J23, J38, J65

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1 Introduction

It is well-known that permanent loss of a long-term job—worker displacement—leads to earnings losses that are enduring, even permanent.[5] But long-standing unanswered questions surround the reasons for these losses. Are they the result of lost specific human capital, lost firm-specific rents, unobserved characteristics of displaced workers, or something else? Longitudinal data on workers' earnings have established the magnitude of displaced workers' earnings losses, but they have not been able to answer questions about the reasons for these losses, which are important both theoretically and from the standpoint of mitigating the losses.

In this paper, we use linked employer-employee panel data based on administrative records from the unemployment insurance (UI) system of Washington State (both wage records and UI claims records from 2002–2014) to obtain evidence on the sources of dislocated workers' earnings losses. The Washington administrative records are unusual because, in addition to reporting employer-specific quarterly earnings of all UI-covered workers in the state, they also report quarterly work hours. The availability of both earnings and work hours allows calculation of hourly wage rates on a quarterly basis; this in turn allows us to decompose displaced workers' long-term earnings losses into components due to reduced hours and lower hourly wages.

The Washington data also give us the opportunity to make headway in understanding the role of employers in generating earnings losses by allowing estimation of worker- and employer-specific fixed effects—the Abowd, Kramarz, and Margolis (1999) (AKM) approach. The

[5] See, for example, Topel (1990), Jacobson, LaLonde, and Sullivan (1993a, 1993b), Farber (1993, 1997, 2015, 2017), Stevens (1997), von Wachter, Song, and Manchester (2009), Couch and Placzek (2010), Davis and von Wachter (2012), and the reviews by Hamermesh (1996), Fallick (1996), Kletzer (1998), von Wachter (2010), and Carrington and Fallick (2017). Worker displacement has also been shown to reduce household expenditure (Stephens 2001), lead to poorer health (Schaller and Stevens 2015), reduce happiness (Kalil and DeLeire 2013), increase mortality (Sullivan and von Wachter 2009), and harm children affected by parental job loss (Oreopoulos, Page, and Stevens 2008; Stevens and Schaller 2011).

estimated employer fixed effects allow us to observe whether displaced workers are separating from employers who pay premium earnings and wages, and finding reemployment with employers who do not. Widely accepted interpretations of the employer fixed effects allow us to infer the extent to which earnings losses stem from lost firm-specific rents or, alternatively, lost firm-specific human capital.

We find that workers displaced in Washington during the Great Recession suffered earnings losses similar to those in Pennsylvania during the 1980s (Jacobson, LaLonde, and Sullivan (1993a, 1993b) (hereafter, JLS), in Connecticut during 2000–2001 (Couch and Placzek 2010) (hereafter, CP), and in the U.S. (nationally) over the 1980–2005 period (Davis and von Wachter 2012): five years after job loss, displaced workers' earnings were 16 percent less than those of a stably employed comparison group.[6] The decomposition of these losses into hours and wage rates reveals that virtually all earnings losses in the year following displacement resulted from lost work hours. But the picture changes substantially over time: five years after displacement, about 45 percent of lost earnings were due to reduced work hours, and about 55 percent were due to lower hourly wage rates.[7] Moreover, the pattern of displaced workers' wage rate losses differs markedly from that of earnings losses: whereas earnings follow a well-known pattern of "dip, drop, and partial recovery," wage rates drop suddenly at the time of displacement and recover hardly at all.

Consistent with the recent literature on firm-specific earnings differentials (e.g., Card, Heining, and Kline 2013; Card, Cardoso, and Kline 2016; Sorkin 2016, Barth et al. 2016; Goldschmidt and Schmieder 2017; Fackler et al. 2017), the estimates suggest that employer fixed

[6] JLS and CP also use administrative records, so we will draw frequent comparisons between our estimates of displaced workers' earnings losses and theirs.
[7] This differs from Stevens's (1997) findings using the Panel Study of Income Dynamics, which suggest that reduced work hours play a relatively minor role in explaining the long-term earnings losses of displaced workers.

effects play a significant role in explaining displaced workers' earnings losses. Specifically, in the long run, employer fixed effects account for about 11 percent of the *average* displaced worker's lost earnings and about 25 percent of their reduced wage rates. For workers displaced from employers paying top-quintile earnings premiums (nearly 60 percent of the displaced workers in the sample), the contribution of lost employer-specific premiums is large and striking: for these workers, more than half of earnings losses and 83 percent of lower long-term hourly wages can be attributed to lost employer-specific premiums. That is, a majority of displaced workers in the sample separated from a high-premium employer, and more than half of the losses of these workers can be attributed the foregone employer-specific fixed effects.

Overall, the findings suggest that, for the average displaced worker, lost firm-specific human capital (or possibly lost match-specific fixed effects) is more important than lost firm-specific rents in explaining lost earnings. In contrast, for workers displaced from employers paying top-quintile earnings premiums, foregone firm-specific rents are central to lost earnings.

The paper is organized as follows. Section 2 describes the data, and section 3 describes the empirical strategy. This starts with JLS's seminal approach, which we extend to a decomposition of earnings losses into components attributable to lost work hours and reduced wage rates. We then combine the JLS approach with the AKM model to examine the importance of employer fixed effects in explaining the losses of displaced workers. Section 4 presents the main results on earnings losses and their decomposition into effects due to lost work hours and lower hourly wage rates. Section 5 examines the importance of employer-specific fixed effects in explaining the losses of displaced workers. The final section reviews the estimates and discusses their implications.

2 Data

The data we use come from the records maintained by the Employment Security Department of Washington State to administer the state's UI system: quarterly earnings records from all UI-covered employers in Washington from 2002:I through 2014:IV; and the UI claims records of all individuals who claimed UI in Washington at any time during the same period.

The administrative records of most states include only a worker's quarterly earnings by employer; however, UI-covered employers in Washington are required to report each worker's quarterly work hours in addition to quarterly earnings.[8] Hence, a record appears for each quarter-worker-employer combination that includes information on the worker's earnings and work hours during the quarter with the specified employer. This is a distinctive advantage of the Washington administrative data, making it possible to construct an hourly wage rate in quarter *t* for most workers in Washington's formal labor market. Specifically, we rely on the wage rate with the primary employer in each quarter (that is, the employer from whom the worker had the largest share of earnings in a given quarter), dividing earnings from that employer by hours worked with that employer.[9]

The wage records include an employer identifier and the four-digit North American

[8] Washington is the only state that uses hours worked in the year before claiming UI to determine UI eligibility, so employers are required to report hours, including overtime hours and hours of paid leave. Actual hours of salaried, commissioned, and piecework employees are reported unless those hours are not tracked, in which case employers are instructed to report 40 hours per week—see *Unemployment Insurance Tax Information*, Employment Security Department, Washington State, October 2014 (Revised). Our examination of the hours data starting in 2001 suggests they are reliable and of high quality—see Lachowska, Mas, and Woodbury (2017). For further discussion of Washington's UI system, see Lachowska, Meral, and Woodbury (2016).

[9] All earnings are converted to constant 2010 dollars using the Consumer Price Index for All Urban Consumers (CPI-U). We handle outliers by winsorizing positive earnings at the 99th percentile (about $69,000 per quarter). Work hours coded "9999" are set to missing. Most observations with positive earnings and zero hours in a quarter are accurate: the Washington Employment Security Department instructs employers to report back pay, bonuses, commissions, cafeteria and 401k plan payments, royalties and residuals, severance and separation pay, settlements, sick leave, and tips and gratuities as quarter *t* earnings if they were paid in quarter *t*, even if the worker no longer worked for the employer in quarter *t* (see https://esd.wa.gov/employer-taxes/zero-hour-reports). Finally, we winsorize positive hours at the 99th percentile (783 hours per quarter) and winsorize positive wage rates at the 99 percentile (about $139 per hour).

Industry Classification System (NAICS) code of each employer. These make it possible to construct employment at the employer level by summing over the records associated with a given employer in each quarter.

At the worker level, the employer identifiers and NAICS codes, along with the panel nature of the administrative records, allow us to observe worker transitions between employers and industries. The panel nature of the wage records also allows us to observe each worker's tenure with a given employer.

UI administrative records rarely include demographic characteristics. Rather, states typically record worker characteristics only when a worker claims UI benefits and registers for employment services through the public labor exchange. For that reason, we know worker characteristics—age, gender, race, education—only for the subset of workers who claimed UI and registered with the public labor exchange at some point during 2002–2014. For gender and race, we assign an indicator with a constant value throughout the 13-year period. We assign the age of a worker in each quarter based on the worker's age in the quarter he or she was observed. For education, we assign a constant level if we observe the worker only once; however, if we observe the worker more than once (that is, if he or she claimed UI more than once), we assign the first observed value of education for all quarters until the quarter in which we observe a change.

The advantages of the Washington administrative data are substantial—they provide information on the earnings and work hours of virtually all workers employed in Washington over a period of 13 years, as well as information on all UI-covered employers in the state.[10]

[10] Exemptions from coverage are limited to the self-employed, including outside sales workers paid solely by commission and independent contractors meeting exemption tests specified in Washington's UI law (Revised Code of Washington, Title 50). Nonprofit religious organizations are also exempt.

Nevertheless, three shortcomings common to UI administrative records are also clear: demographic information is available for only a subsample, the data are restricted to a single state, and information on workers who leave Washington (or leave formal employment for self-employment or the informal sector) are not available.[11]

We use the Washington administrative records just described for two distinct analyses: an AKM analysis, which estimates employer fixed effects for earnings, work hours, and wage rates using data on all UI-covered workers and employers in Washington; and an analysis of displaced workers' earnings losses, part of which makes use of the AKM analysis. In the rest of this section, we focus on describing the sample used in the displaced worker analysis. The dataset used in the AKM analysis is far larger and is described in Appendix B, along with the AKM analysis itself.

2.1 Construction of the displaced worker analysis sample

We follow JLS and CP in focusing on long-tenure workers, defined as workers with at least six years of job tenure (24 consecutive quarters of positive earnings) with the same primary employer during 2002–2007.[12] Specifically, all workers in the analysis sample (both displaced and non-displaced) have positive earnings or hours with the same primary employer in all quarters from 2002:I–2007:IV.

We define a long-tenure worker as displaced if, at any time during 2008–2010, that worker separated from her primary employer within four quarters of a quarter in which that employer experienced a mass layoff (as defined next). We focus on separations during 2008–

[11] As discussed below, this last issue can be mitigated by restricting the analysis sample of the displaced workers to have at least one quarter of positive earnings or work hours in each year starting in 2008. We also check the sensitivity of the estimates to selective attrition (see section 4.5).
[12] In section 4.4, we develop estimates for displaced workers with shorter previous job tenures.

2010 because, although the Great Recession contraction officially lasted from December 2007 until June 2009, the recovery of the labor market lagged substantially: the Washington unemployment rate did not fall below 10 percent until June 2010, and had fallen only to 9.6 percent by December 2010 (https://www.bls.gov/lau/). A worker's displacement is dated to the quarter of his or her separation (not the quarter of the separating employer's mass layoff). Workers who separated, but not in connection with a mass layoff, are dropped from the displaced worker "treatment" group because, for these workers, the decision to separate is more likely to have been the result either of worker choice or employer selection.

An employer is counted as having a mass layoff in a quarter in which two conditions are met (Davis and von Wachter 2012). First, during 2008–2010, employment must have dropped by 30 percent or more compared with the quarter of 2007 in which employment was greatest. Second, the employer's maximum employment in 2007 must have been less than 130 percent of that employer's maximum employment in 2006. The second condition helps to avoid classifying employers in steady decline as experiencing a mass layoff.

Because this definition of mass layoff hinges on percentage changes in the *level* of employment, small employers may be counted as having a mass layoff with only a small absolute change in employment. Accordingly, we drop from the analysis any worker who at any time had a primary employer whose employment dropped below 50 workers in any quarter during 2002–2007.

For all quarters starting with 2008:I, we require displaced workers to have at least one quarter per calendar year with positive earnings or hours to remain in the sample. This again follows JLS and implies that the estimates should be interpreted as effects of displacement on

workers who remain attached to the Washington labor force.[13] (In section 4.5, we estimate the effects of displacement without imposing this requirement.)

The comparison group consists of long-tenure workers (at least six years of tenure with the same primary employer between 2002–2007) who were not displaced and who continued to have positive earnings with the same primary employer in every quarter from 2008:I through 2014:IV. The comparison, then, is between the outcomes of long-tenure displaced workers and long-tenure non-displaced workers who retain employment with the same primary employer for another seven years.[14] [15]

About one-third of the workers who we count as displaced claimed UI benefits and registered with the public labor exchange at some time during 2002–2014. We focus on this UI claimant sample because (as described above) we observe these workers' age, race, sex, and education. This allows us to perform subgroup analyses, as well as to make our analysis similar to previous research by restricting attention to displaced workers aged 20–50 at the time of displacement (and non-displaced workers aged 20–50 in 2007:IV).[16]

[13] Workers who drop out of the labor force, become self-employed, work in the underground economy, or move out of state will not appear in the Washington wage records. (Self-employed workers are not covered by UI, underground earnings are not reported, and out-of-state earnings will be picked up in the wage records of another state.)

[14] We have also developed estimates using a broader comparison group that need not remain with the same primary employer from 2008:I through 2014:IV—see Appendix C. Specifically, the comparison group includes long-tenure workers who separated (but not in connection with a mass layoff) during 2008:I through 2010:IV or who separated *for any reason* after 2010:IV. Because this comparison group is defined without conditioning on continuous future positive earnings or hours, estimated earnings losses are somewhat smaller than those estimated using the first comparison group. Krolikowski (2018) discusses the choice of a comparison group for displaced workers in greater detail.

[15] We have conducted a robustness check that excludes the non-displaced co-workers of displaced workers from the comparison group. This exclusion drops about 20 percent of the original comparison group, and produces slightly larger estimates of displaced workers' earnings, hours, and wage rate losses.

[16] Estimates using a broader (and considerably larger) sample—that is, not restricted to UI claimants—are similar to those obtained using the UI claimant sample. See Appendix Figures A.4, A.5, and A.6.

2.2 Summary statistics for displaced workers and the comparison group

Table 1 displays descriptive statistics of key variables for the full UI claimant sample (columns 1 and 2) and for two subsamples we examine later for reasons that will become clear: the UI claimant sample excluding workers in NAICS industries 51–56 (information, finance and insurance, real estate, professional, scientific, and technical services, management of companies; administrative, support, and waste management and remediation services—columns 3 and 4); and workers whose employers paid top-quintile earnings premiums (see section 3.2—columns 5 and 6). The full UI claimant sample includes 3,032 displaced workers and 13,290 non-displaced workers. Note that all workers in the non-displaced comparison group claimed UI at some time during our observation window, as did the displaced workers. Inspection of the data shows that the non-displaced workers who claimed UI experienced relatively short spells of unemployment before being recalled to the employer from whom they were laid off.[17]

The top panel of Table 1 shows sample means and standard deviations of workers' quarterly average earnings, work hours, and hourly wage rate for the pre-displacement years 2002–2005. (We omit 2006–2007 to avoid including lower earnings and hours that may occur due to pre-displacement "Ashenfelter's dips.") Displaced workers had somewhat higher earnings and work hours, and substantially higher hourly wage rates, than did non-displaced workers. These differences nearly disappear, however, when workers in NAICS industries 51–56 are dropped from the sample (columns 3 and 4).

The demographic characteristics of the UI claimant sample fit the well-known profile of displaced workers: 70 percent male, 77 percent white, 45 percent with a high school education but no post-secondary education, 11 percent with less than high school or a GED, and averaging

[17] The median UI claim duration of non-displaced workers in the sample was 2 weeks, whereas median UI claim duration of displaced workers in the sample was 4 weeks.

40 years of age.

The bottom panel of Table 1 shows two substantial differences between the displaced worker sample and the non-displaced comparison group. First, the employers of displaced workers were smaller on average than those of non-displaced workers. This difference arises because, as noted earlier, small employers are more likely than large employers to satisfy the definition of a mass layoff. Second, the distribution of displaced and non-displaced workers differs by major industry of employment in 2007:IV. About 83 percent of displaced workers came from just three major industries: NAICS codes 31–33 (manufacturing; 27 percent), 42–49 (trade; 15 percent), and 51–56 (information, finance and insurance, real estate, professional services, management, and administrative support; 41 percent). In contrast, only two-thirds of the non-displaced comparison workers worked in these industries. The imbalance results mainly from NAICS industries 51–56, which employed 41 percent of the displaced workers, but only 6 percent of the non-displaced comparison group. The relative dearth of stably employed workers in NAICS industries 51–56 who are available for comparison with workers displaced from NAICS industries 51–56 suggests that employment in those industries is less durable than employment in industries, like manufacturing, from which workers traditional have been displaced.

The composition of displaced workers in the Washington samples differs sharply from the composition of the Pennsylvania workers examined by JLS, 75 percent of whom came from manufacturing; however, in the Connecticut sample analyzed by CP is more like the Washington sample: 16 percent from manufacturing, 19 percent trade, and 23 percent from NAICS codes 51–56. As a check on the overall estimates, we conduct an analysis of workers displaced from all industries except NAICS 51–56 in section 4.3.

3 Estimation methods

This section begins with a description of methods used to estimate the effects of displacement on earnings. We next discuss the decomposition of earnings losses into components due to lower work hours and hourly wage rates. We then describe our use of AKM methods to estimate the importance of employer effects in displaced workers' employment outcomes.

3.1 Estimated displacement effects on earnings, hours, and wage rates

To estimate displaced workers' earnings losses, we apply the multi-period difference-in-differences estimator from JLS, which compares the employment outcomes of displaced workers before, during, and after displacement with observationally similar long-tenure workers who were not displaced. For the UI claimant subsample, the effect of displacement can be obtained by estimating a worker fixed-effects model of the following form:

$$Y_{ijt} = c_i + \gamma_t + \mathbf{Z}_{it}\boldsymbol{\theta}_1 + \mathbf{W}_{it}\boldsymbol{\theta}_2 + \mathbf{X}_{j(i,t)}\boldsymbol{\beta} + \sum_{k=-20}^{20}(\delta_k \cdot D_{itk}) + e_{ijt} \quad (1)$$

where Y is an employment outcome (earnings, hours, or wage rate) of worker i (with primary employer j) in quarter t; c_i is a worker-specific fixed effect; γ_t is a vector of calendar quarter indicators; $\mathbf{Z}_{it}$ includes the worker's age and age squared, and a vector of gender, race, and education indicators, interacted with the worker's age; $\mathbf{W}_{it}$ includes averages of the worker's pre-displacement (2002–05) earnings and pre-displacement hours with the primary employer, both interacted with a vector of yearly indicators; and $\mathbf{X}_{j(i,t)}$ consists of the characteristics of worker i's pre-layoff employer j (logarithm of employer size and one-digit NAICS code in 2007:IV interacted with a vector of yearly indicators). Each D_{itk} is an indicator equal to one if the worker is observed in quarter k relative to displacement, zero otherwise ($k = 0$ is the quarter of

displacement).[18] (The estimating equation for the full sample is the same as equation (1) except that we necessarily drop worker characteristics $\mathbf{Z}_{it}$.) Because we cannot assume the regression errors e_{it} are independent over time, we cluster standard errors at the individual worker level.

Interest lies mainly in the estimates of δ_k, which are regression-adjusted differences in outcomes between displaced and non-displaced workers before ($k < 0$), at the time of ($k = 0$), and after ($k > 0$) the quarter of displacement. Interpreting the estimated δ_k as causal effects of displacement requires the assumption that, absent displacement, the time path of displaced workers' employment outcomes would have remained parallel to the time path of non-displaced workers' outcomes. By differencing away any pre-displacement gap between displaced and stably employed workers, we can interpret post-displacement differences in outcomes as the effect of displacement. In practice, if we observe negative estimated δ_ks after displacement, but not in the years preceding displacement, we take this as evidence of a displacement effect.[19]

Figure 1 illustrates the parallel-trends assumption using earnings (unconditional on employment, so including zero earnings) and hours data for workers displaced in 2009:I and workers who remain stably employed by the same employer. During the first 5–6 years of the seven before displacement, the earnings and hours of workers who will be displaced and those who will remain stably employed are roughly parallel. The profiles of both earnings and hours give a first impression that, following displacement, workers' earnings and hours worked tend not to recover to their pre-displacement levels.

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[18] The omitted reference category consists of non-displaced workers and all observations recorded in quarters 21, 22, 23, and 24 before the displacement ($k < -20$); hence, we limit the analysis sample to observations recorded between –24 and 20 quarters relative to the displacement quarter.

[19] As a robustness check of the parallel-trends assumption, we also estimate a version of the worker fixed-effects difference-in-differences model with worker-specific trends (a "random trend" model):

$$Y_{it} = c_i + \omega_i t + \gamma_t + \sum_{k=-20}^{20}(\delta_k \cdot D_{itk}) + e_{it}\,, \qquad (2)$$

where t is a (quarterly) time trend, ω_i is a worker-specific annual growth rate over the period, and γ_t is a vector of calendar quarter indicators. [Other notation is the same as for equation (1).] In practice, we de-mean all variables in equation (2), then apply a fixed-effects estimator to the de-meaned data; see JLS (1993a, p. 694), Wooldridge (2002, pp. 315–317). Results are shown in Appendix Figures A.1, A.2, and A.3.

Because earnings are the product of hours worked and the hourly wage rate, the time paths of earnings and work hours imply a time path of the hourly wage rate. Accordingly, we plot the estimated time paths of earnings and of work hours for each phase of the displacement process, then obtain the time path of wage rates as a residual. We also estimate the time path of hourly wage rates directly using models like equation (1) for the level and log of hourly wage rates, recognizing that these estimates are conditional on employment.

3.2 Employer fixed effects

A growing body of research has examined the importance of employers in earnings determination (e.g., Abowd, Kramarz, and Margolis 1999; Card, Heining, and Kline 2013; Card, Cardoso, and Kline 2016; Sorkin 2016; Barth et al. 2016). In general, this line of research has shown that "where you work" is important to "what you earn." The Washington data allow us to construct a linked employer-employee panel and estimate AKM models of earnings, hours, and hourly wages using data for 2002–2014 (see Appendix B for details). The resulting estimated employer fixed effects allow us in turn to observe the extent to which the earnings, hours, and wage-rate losses of displaced workers result from working for post-displacement employers with policies regarding earnings, hours, and wage rates that differ systematically from the pre-displacement employer.

The AKM models we estimate can be written:

$$\log Y_{ijt} = \alpha_i + \psi_{j(i,t)} + \theta_t + u_{ijt} \,, \tag{3}$$

where Y is an employment outcome (earnings, hours, or the wage rate) of worker i (with primary employer j) in year t; α_i is a worker-specific fixed effect (reflecting the productive characteristics of the worker that can be transferred between employers); $\psi_{j(i,t)}$ is an employer-specific fixed

effect (reflecting employer characteristics that result in above- or below-average earnings, hours, or wage rates for all workers at employer j); θ_t is a vector of calendar year indicators; and u_{it} is the error component. The function $j(i,t)$ indexes the employer effect for worker i in year t.[20]

Estimation of equation (3) for each of the three outcomes results in three vectors of estimated employer fixed effects ($\widehat{\psi}_j$) one each for the log of earnings, log of hours, and log of wage rates (all necessarily conditional on employment). The estimated employer fixed effects for earnings or wage rates can be interpreted as measures of the advantages—premiums or rents—derived from being employed by a given employer. The estimated employer fixed effects for hours represent employers' differing policies regarding work hours. The estimates of employer fixed effects for earnings, hours worked, and wage rates are the parameters of main interest in equation (3).[21]

To estimate equation (3), we apply Card, Heining, and Kline's (2013) algorithm for estimating the AKM model, which is based on Abowd, Creecy, and Kramarz (2002).[22] The employer effects in equation (3) are identified only within a "connected set" of employers—that is, employers linked by worker transitions. We restrict the analysis to the largest connected set, which consists of 64 percent of all employers and about 90 percent of all workers in Washington. [These percentages are similar to those obtained by Sorkin (2016) using the U.S. LEHD data for

[20] To reduce the computational burden, we estimate equation (3) using annualized data; see Appendix B. Note that because we do not have demographic information for most workers in dataset used for the AKM analysis, equation (3) includes no demographic controls. We show in Appendix B that the variance decomposition of earnings in the Washington data (without demographic controls) is very similar to that obtain by Sorkin (2016) using U.S. LEHD data for 2000–08.

[21] See Goldschmidt and Schmieder (2017), who take a similar approach to estimate the loss of employer-specific effects due to outsourcing of jobs, and Fackler et al. (2017), who study employer-specific effects for workers displaced in connection to employer bankruptcy.

[22] The Card, Heining, and Kline algorithm is coded in MatLab and uses tools from graph theory to find the largest connected set, then estimates the fixed effects by solving the normal equations numerically (incomplete Cholesky factorization with preconditioned conjugate gradient, which is good for situations where the matrix is large but sparse). We have used an adapted version of the MatLab code available on Patrick Kline's website: http://eml.berkeley.edu//~pkline/papers/code_CHK.zip (last accessed: December 7, 2016).

2000–08.] To avoid creating a mechanical relationship between earnings changes and estimated ψ_js, we exclude displaced workers and the non-displaced comparison group when estimating the AKM model.

We treat the estimated employer fixed effects, $\widehat{\psi}_j$, as additional outcomes of the displacement process: the question is, what proportion of the earnings, hours, and wage rate losses following displacement can be attributed to a displaced worker's reemployment by an employer with a different $\widehat{\psi}_j$ (for earnings, hours, or wage rates) than the employer from which she was displaced. We begin by assigning the appropriate $\widehat{\psi}_j$s (for employer j) to each worker-quarter observation in the displaced worker data. It is possible to assign $\widehat{\psi}_j$s to all worker-quarter observations in the pre-displacement period (2002–2007) and to all but 622 worker-quarter observations in the post-displacement period. (All 622 observations are for displaced workers in the post-displacement period, from a total of 71,819 worker-quarter observations of displaced workers in the post-displacement period.) The unmatched cases occur when the employer of a displaced worker was not in the connected set used to estimate the AKM $\widehat{\psi}_j$s. There are 124 such employers, and they employed altogether 160 unique displaced workers for at least one quarter following displacement.[23]

To estimate the importance of employer-specific fixed effects in explaining the adverse outcomes of displaced workers, we compare the employer fixed effects (for earnings, hours, and

[23] When we estimate the AKM model using data only from the pre-displacement years (2002–2007), rather than from all available years (2002–2014), we are unable to match 22,806 worker-quarter observations for 1,762 unique displaced workers who were employed by 834 employers in the post-displacement period. For these 834 employers, $\widehat{\psi}_j$s could not be produced either because they were not in the connected set or because they did not exist before 2008. (As with the 2002–2014 data, 2002–2007 data produces $\widehat{\psi}_j$s for all pre-displacement employers.) The correlation coefficients between $\widehat{\psi}_j$s estimated using 2002–2014 data and $\widehat{\psi}_j$s estimated using 2002–2007 data are 0.98 for log earnings, 0.96 for log hours, and 0.96 for log wage rates.

wage rates) of displaced workers after displacement with the employer fixed effects before-displacement (and relative to the employer fixed effect of workers not displaced). That is, for every quarter *k* relative to displacement, we compute:

$$\mathrm{E}\left[\psi_j \mid \alpha_i, \theta_t, D_{itk} = 1\right] - \mathrm{E}\left[\psi_j \mid \alpha_i, \theta_t, D_{itk} = 0\right],$$

where D_{itk} equals one if the observation is for a displaced worker observed in a post-displacement quarter, and zero if the observation is for a stably employed worker or a displaced worker observed in a pre-displacement quarter. In practice, we regress the estimated employer fixed effect $\widehat{\psi}$ on pre- and post-displacement indicators, along the lines of equation (1):

$$\widehat{\psi}_{ijt} = c_i + \gamma_t + \mathbf{Z}_{it}\boldsymbol{\theta_1} + \mathbf{W}_{it}\boldsymbol{\theta_2} + \mathbf{X}_{j(i,t)}\boldsymbol{\beta} + \sum_{k=-20}^{20}(\delta_k \cdot D_{itk}) + e_{ijt} \qquad (4)$$

The estimated δ_ks are regression-adjusted differences in employer fixed effects realized by displaced workers relative to non-displaced workers and relative to before displacement. Equation (4) includes individual worker fixed effects, so the estimated δ_ks represent within-worker changes in employer fixed effects (for earnings, hours, and wage rates) resulting from transitions from pre- to post-displacement employers. For earnings and wage rates, we interpret negative estimated δ_ks as evidence of lost employer-specific premiums (which could result from lost rents or compensating differentials; see Sorkin 2016). For hours worked, we interpret negative estimated δ_ks as evidence of reduced hours due to the working time policies of post-displacement employers.

4 Estimated effects of displacement on earnings, work hours, and wage rates

This section presents estimates of the magnitude of displaced workers' earnings losses and decomposes those losses into their work-hour and hourly wage rate components. We also examine the effects of displacement on "traditional" displaced workers (that is, workers displaced from industries other than NAICS industries 51–56), workers with relatively short pre-displacement job tenure, and workers with relatively weak labor force attachment. In section 5, we examine the extent to which displaced workers' earnings losses can be attributed to employer fixed effects.

4.1 Estimates of lost earnings

Figure 2 displays estimated effects of displacement on unconditional earnings (top) and log earnings (bottom) over a period of 5 years, and Table 2 offers a summary of the estimates for the quarter following displacement (quarter 1) and the average of quarters 17–20 following displacement. The graphs are obtained by estimating equation (1) and plotting the estimated δ_ks, along with 95-percent confidence intervals (which are very small and at times hard to see). The vertical line in each graph marks the quarter of displacement; that is, the last quarter in which a displaced worker is observed with earnings or hours with the employer of the previous six years.

A clear pattern emerges from Figure 2. Soon-to-be-displaced workers' earnings dip (or drift downward slightly) in roughly the year before displacement (Ashenfelter's dip), drop sharply in the quarter of displacement and the quarter immediately following displacement (quarters 0 and 1), then recover, but never to their pre-displacement level, as gauged relative to earnings of the comparison group. It follows that the earnings losses of displaced workers have three sources: Ashenfelter's dip before displacement (which is small in this case), the drop at and

immediately after separation, and most significantly, the long-term earnings deficit after reemployment (see again Figure 1).

The top graph in Figure 2 shows that, in the quarter following displacement, workers lost on average about $5,960 compared with comparable non-displaced workers. (See also the top panel of Table 2 and Appendix Table A.1.) Dividing this by pre-displacement (2002–05) average earnings with the former primary employer ($12,482, from Table 1) implies a loss of about 48 percent in the quarter following displacement. Estimates for the log of earnings are somewhat smaller than the other estimates, suggesting that, in the quarter after displacement, earnings are on average less than those of the comparison group by about 39 percent [exp(–0.488) – 1]; however, because these estimates condition on positive earnings, they understate the extent of earnings losses.

The above estimate of earnings losses in quarter 1 is based solely on earnings from the primary employer in the quarter following displacement. (This employer by definition cannot be the employer from which the worker was displaced.) If we instead examine earnings from all post-displacement employers, estimated earnings losses are similar, although somewhat smaller (see again Appendix Table A.1). This suggests that accounting for the presence of multiple employers does not substantially change the conclusions drawn from focusing solely on outcomes from primary employers.

Figure 2 and Table 2 also shows that, five years after displacement, displaced workers earned on average $1,940 less per quarter from their primary employer than did comparable non-displaced workers. This translates to lost earnings of about 16 percent (dividing by $12,482). The

log earnings estimates suggest long-term losses of about 15 log points.[24] As was true for earnings in the quarter after displacement, estimated long-term earnings losses based on earnings from all employers are very similar to those based on earnings losses from only the primary employer (Appendix Table A.1).

Table 3 compares the estimates in Figure 2 and Table 2 with those obtained by JLS and Couch and Placzek (2010, hereafter "CP"), the studies most similar to ours. JLS (1993b, Figure 5.5) report that, at the time of displacement, their sample of Pennsylvania UI claimants experienced a drop in earnings of about $7,800 (in 2010 dollars, $4,000 in 1987 dollars), and five years after the displacement, their earnings remained about $2,900 (in 2010 dollars, $1,500 in 1987 dollars) lower than they would have been otherwise. CP (Figure 4) show that, immediately following displacement, the quarterly earnings of their sample of Connecticut UI claimants were about $7,700 (in 2010 dollars; $6,000 in 2000 dollars) less than they would have been otherwise—a 49 percent deficit. Five years after displacement, these workers still earned about $5,100 (in 2010 dollars; $4,000 in 2000 dollars) less than otherwise—a 32 percent deficit.

The earnings losses we estimate for Washington workers displaced in 2008–2010 are somewhat smaller than those reported by either JLS or CP, but the similarities are perhaps more striking than the differences.[25]

[24] Appendix Figures A.1–A.3 repeat the analysis in Figures 2–4 using the random trend model; see equation (2). The estimated time paths are similar to those estimated using equation (1). This similarity suggests that, before displacement—and conditional on characteristics of the worker and pre-layoff employer ($\mathbf{Z}_{it}$ and $\mathbf{X}_{ijt}$)—earnings and work hours of displaced and non-displaced workers evolve approximately in parallel. This tends to buttress the interpretation of post-displacement outcome differences between displaced and non-displaced workers estimated using model (1) as the effects of displacement.

[25] The JLS sample consists largely of workers displaced from manufacturing in Pennsylvania during the time of the decline of the U.S. steel industry, and the CP sample, although more diverse, consists disproportionately of workers displaced from shipbuilding during the 2001 recession. No single industry in Washington imploded during the Great Recession, although Washington clearly experienced a severe contraction.

4.2 Estimates of lost work hours and reduced hourly wage rates

Figure 3 displays estimated effects of displacement on unconditional work hours (top) and log hours (bottom), again based on equation (1). (See also the top panel of Table 2. Appendix Table A.2 shows the estimates in detail.) As was true for earnings, the work hours of soon-to-be-displaced workers dip somewhat in roughly the year before displacement, drop greatly in the quarter of displacement and the quarter following displacement, then partially recover. The recovery of work hours appears more robust than the recovery of earnings, but work hours of the displaced workers nevertheless remain below those of the non-displaced comparison group.

A comparison of Figures 2 and 3 suggests that most of the earnings losses in the quarter of displacement and the quarter following can be explained by lost work hours. Lost hours in the quarter after displacement amount to 200 hours on a base of 500 hours (40 percent, estimated in levels), or about 38 log points. The corresponding earnings losses are about 48 percent (in levels), or about 49 log points, so we infer that lost work hours are responsible for roughly 80 percent of lost earnings around the time of displacement.

Five years after displacement, reduced work hours remain an important reason for lost earnings. Figure 3 shows that after five years (in quarters 17–20), the average displaced worker still works 29 fewer hours per quarter than otherwise (about 6 percent, estimated in levels), or about 7 log points. The corresponding earnings losses are about 16 percent (in levels), or about 15 log points, so we infer that reduced work hours account for about 45 percent (7 out of 15 log points) of the long-term earnings losses of displaced workers. It follows that the remaining 55 percent of long-term earnings losses are accounted for by lower hourly wage rates (see below).

These estimates may be surprising in light of Stevens's (1997) finding that reduced work hours (as opposed to declining wage rates) play a relatively minor role in explaining displaced

workers' long-term earnings losses. However, Farber (2017) also finds that reduced hours (conditional on working) are a factor in explaining earnings losses—specifically, he finds that the movement from full-time to part-time employment explains a significant part of the cost of displacement during and after the Great Recession.[26]

To further investigate displacement's effects on work hours, we estimate a set of linear probability models, based on equation (1), using indicators of whether a worker's weekly work hours (averaged over a quarter) exceeded a given threshold. In particular, we estimate models for weekly hours exceeding, 0, 10, 20, 30, 35, 40, 45, 50, and 60. The estimates are displayed in Table 4 and suggest three main points about the way displacement changes the distribution of hours in the long-term (quarters 17–20). First, the overall long-term loss of work hours appears not to be driven by non-employment (i.e., more workers with 0 hours): although displacement reduces the probability of any work (Hours > 0) by about 2 percentage points in quarters 17–20, this is a small reduction in proportional terms (0.02 on a base of 0.996). Second, the main effect of displacement is to reduce the probability of working at least 20, 30, 35, and 40 hours per week. This is surprising because displacement implies lost seniority, which would imply loss of overtime hours, but it appears not to be the case. In fact, the estimates for hours in excess of 50 and 60 suggest that displacement may slightly *increase* the probability of work hours at the high end of the hours distribution; that is, if anything displaced workers are slightly more likely to work overtime after displacement. This is the third main implication of the estimates in Table 4.

[26] Farber's (1993, 2015, 2017) studies makes use of the Displaced Worker Supplement to the Current Population Survey, so they pertain to are broader group of workers—those who previously lost jobs due slack work, plant closing, or elimination of a position or shift—than the studies using UI administrative data, which are restricted to long-tenure workers who separate in connection with the employer experiencing a large contraction. For this and other reasons, comparisons between Farber's estimates and those presented here are not straightforward.

The conclusion above—that displaced workers' reduced hours explain about 45 percent of their long-term (five-year) earnings deficit—implies that lower hourly wage rates should explain the remaining 55 percent of the long-term earnings deficit. As a check, Figure 4 shows estimated hourly wage rate losses from equation (1) estimated using the log of the hourly wage rate as the dependent variable. The results suggest that, five years after displacement, hourly wage rates are about 8 log points lower than otherwise (see the top panel of Table 2). These estimates are best compared with those using log earnings and log hours as outcomes (since they are also conditioned on employment), and together they again imply that about 45 percent of the long-term earnings deficit of 15 percent is due to fewer work hours, and about 55 percent to lower hourly wage rates.[27] Together, the long-term time paths of log hours worked and log hourly wage rates imply a high labor supply elasticity. We return to this point in section 4.4.

The estimated hourly wage profile (Figure 4) differs from both the earnings profile in Figure 2 and the work hours profile in Figure 3. Following displacement, log hourly wage rates drop immediately by about 10 percent and remain permanently lower by about 7 percent. This differs from the earnings and hours profiles, which first drop, then partially recover after two years. We explore whether employer fixed effects are the source of this persistent long-term drop further in Section 5.

[27] Figure 4 also shows a clear 6 log-point spike in hourly wage rates in the quarter of displacement (quarter 0). This spike results from a greater drop in work hours than in earnings in the quarter of displacement: for example, Figure 2 shows an earnings drop of about 36 log points in quarter 0, whereas in Figure 3 shows a work-hours drop of about 40 log points. Severance payments paid in the quarter of separation are the most likely cause of this pay bump. Severance payments are included with earnings in administrative wage records and would inflate reported earnings relative to work hours in the quarter of separation. The result is an apparent increase in the hourly wage around the time of displacement.

4.3 Estimates excluding workers displaced from NAICS industries 51–56

To make our estimates more comparable with those of JLS and CP, we repeat the analysis *excluding* workers displaced from jobs in NAICS industries 51–56 (information, finance and insurance, real estate, professional, scientific, and technical services, management of companies; administrative, support, and waste management and remediation services). We do this for two reasons: first, as was seen in Table 1, workers in NAICS industries 51–56 have substantially higher earnings and wage rates than other workers; second, the comparison sample for workers displaced from NAICS industries 51–56 is quite thin, making inferences about the influence of displacement on these workers less convincing than for others.

Figure 5 plots the losses of these "traditional" displaced workers (that is, those displaced from industries other than NAICS 51–56—see also the second panel of Table 2). Figure 5 suggests these workers experience immediate earnings losses of nearly 60 log points, and long-term earnings losses (quarters 17–20) of more than 20 log points. For workers displaced from industries other than NAICS 51–56, then, the long-term losses appear larger than for the overall sample. Still, these estimated long-term losses are somewhat smaller than for the Pennsylvania and Connecticut workers studied by JLS and CP.

Figure 5 shows that the long-term lost work hours and reduced wage rates of traditional displaced workers also exceed those for workers overall. Their long-term hours loss is about 10 log points (compared with 7 log points for all workers), and their long-term wage reduction is about 11 log points (compared with 8 log points for all workers).

4.4 Losses of workers with relatively short job tenure

Displaced workers' long-term losses have been attributed to lost employer-specific and industry-specific human capital (e.g., Topel 1990; Neal 1995; Carrington and Fallick 2017). The implication of the specific human capital hypothesis is that longer pre-displacement tenure is associated with a larger loss of earnings. Farber (1993) found that, on average, each additional year of pre-displacement job tenure was associated with an additional one percent drop in post-displacement earnings. In contrast, in a study using administrative data, von Wachter, Song, and Manchester (2009) find insubstantial differences between the earnings losses of workers with three years of tenure and workers with six or more years of tenure.

We next examine and compare the earnings, hours, and wage rate losses of workers with 6 or more years of pre-displacement job tenure (the main sample) with the losses of workers with only 3–4 years of pre-displacement tenure. To do this, we estimate equation (1) separately for each of the two displaced worker groups (long-tenure and shorter-tenure), using the same non-displaced workers with 6 or more years of tenure as the comparison group. We view this as a descriptive exercise rather than an attempt to estimate the effect of job tenure on the outcomes of displaced workers.

Figure 6 shows the estimated profiles of earnings, work hours, and wage rates (in logs), and the estimated time paths of the quarterly employment probability. The earnings losses and employment probabilities of displaced workers with 3–4 years of tenure are quite similar to those with 6 or more years of tenure, consistent with the findings in von Wachter, Song, and Manchester (2009). However, the patterns of hours losses and wage rate reductions differs sharply between the two groups. The hours losses of short-tenure displaced workers are consistently greater than the hours losses of long-tenure displaced workers. In contrast, the wage

rates of short-tenure displaced workers return to their pre-displacement level within about four years of displacement, whereas the wage rates of long-tenure displaced workers never recover. Further, Figure 6 shows that hourly wage rates of workers with 3–4 years of tenure recover five years after displacement. This differs from the pattern of wage losses experienced by workers with longer tenure and is not explained by a difference in employment probabilities.

One possible interpretation of these estimates is that the reduced work hours of long-tenure displaced workers represent a labor supply response to their reduced wage rates, whereas the substantially reduced hours of short-tenure displaced workers, along with wage rates similar to those faced before displacement, suggests demand constraints faced by these workers. An implication would be that short- and long-tenure displaced workers differ in ways that should not be attributed to previous job tenure alone.[28]

4.5 Losses of workers less strongly attached to the labor force

The main estimates in Figures 2–4 are based on a sample of displaced workers who were employed in at least one quarter per calendar year in each year following displacement. How sensitive are the estimates to this restriction? Relaxing it, so that a displaced worker need never reappear with positive earnings or hours after being displaced, increases the sample of displaced workers from 3,032 to 4,199. Figure 7 plots the estimated time paths of log earnings, log hours, and log wage rates for the unrestricted sample in red, along with the time paths of earnings, work hours, and wage rates for the restricted sample (repeated from Figures 2–4) in blue.

[28] We have also examined losses due to displacement separately for workers younger than age 40 in the quarter of displacement and for workers age 40 and older in the quarter of displacement. (To construct the non-displaced comparison groups, we use age in 2007:IV.) The estimated long-term earnings, hours, and wage-rate losses of the younger and older workers are quite similar, which is surprising because older workers have on average longer job tenure. However, the reemployment rates of older workers in the first two years after displacement are lower than those of younger workers, consistent with Farber's (2017) findings.

The most striking difference between the restricted and unrestricted samples is that, five years after displacement, the probability of employment—defined as having positive earnings or hours in that quarter—for the unrestricted sample is 18 percent less than for the comparison group, compared with 4 percent less for the restricted sample. But differences between the two groups in the time paths of log earnings, log hours, and log wage rates are less striking. Specifically, five years after displacement, earnings are 24 log points lower in the unrestricted sample (compared with 16 log points lower in the restricted sample)[29], hours are 11 log points lower (compared with 7 log points), and wage rates are 13 log points lower (compared with 8 log points).

[29] When Couch and Placzek (2010, p. 579) relax the labor force attachment restriction, they find earnings losses that are greater by 15–18 percentage points, substantially larger than the 8 log-point increase we estimate.

5 Employer fixed effects

Section 3.2 described an approach to estimating whether some portion of displaced workers' losses are due to employer fixed effects. For earnings or wage rates, this would imply loss of a job with an employer offering premium earnings or wage rates, and reemployment with an employer that did not. For hours worked, this would imply loss of a job with systematically longer hours than the job obtained after displacement. This section describes the results of that approach. We first examine whether employer fixed effects are responsible for part of the average displaced workers' earnings losses, lost work hours, and lower hourly wage rates. Second, we examine differences in the importance of employer fixed effects for workers displaced from employers paying high and low earnings premiums. Third, we examine the losses of displaced workers who move to employers offering lower, similar, and higher premiums compared with their pre-displacement employers. Finally, we study the role of industry fixed effects in explaining the losses of displaced workers.

5.1 Estimated losses due to employer fixed effects for the average displaced worker

The blue-dot time paths in the three panels of Figure 8 display estimated effects of displacement on the employer fixed effects ($\widehat{\psi}_j$) for log earnings, log hours, and log of the hourly wage rate for the average displaced worker in the sample. [These are the $\widehat{\delta}_k$s from equation (4), estimated over the sample of all displaced workers who claimed UI.] For comparison with the main results in Figures 2–4, the red-circle time paths in Figure 8 repeat the estimated effects of displacement on log earnings, log hours, and log of the hourly wage rate with the primary employer. [The estimates underlying Figure 8 are reported in Table 5. For each post-displacement quarter, the estimates in the odd-numbered columns give the total log-point changes in earnings (column 1),

hours (column 3), and hourly wage rate (column 5) attributable to displacement, and the even-numbered columns give the log-point changes in earnings (column 2), hours (column 4), and hourly wage rate (column 6) attributable to loss of an employer offering premium earnings.]

For each of the three outcomes, lost employer fixed effects explain a modest (and statistically significant) fraction of the losses due to displacement—see the summary in row B of Table 2. In the quarter following displacement (quarter 1), about 3 log points of the overall earnings loss of 49 log points (or 6.6 percent) are due to working for an employer that pays less to all its workers, controlling for worker fixed effects. For work hours, differing employer hours policies account for about 1.5 of the overall 38 log-point loss (about 4 percent), and lost wage rate premiums account for 1.7 of the overall 11 log-point reduction (about 15 percent).

Twenty quarters after displacement, employer fixed effects play a more important role in the lost earnings and wage rates of the average displaced worker, but essentially no role with respect to lost work hours. Specifically, employer fixed effects account for 1.7 of the overall 15 log-point earnings loss (or 11 percent), and 2 of the overall 8 log-point reduction in hourly wages rates (25 percent). Employer hours policies play no direct role in the loss of work hours. Overall, the estimates suggest that employer fixed effects, although not the main reason for the average displaced workers' long-term losses, nevertheless play some role in those losses.

At the same time, the estimates displayed in Figure 8 suggest an important role for the AKM residual u_{it} (in equation (3)) in explaining the average displaced worker's losses. Because both equations (1) and (4) control for worker fixed effects, the large remaining gap between the overall losses and losses due to employer fixed effects (the gap between the red-circle and blue-dot time paths in Figure 8) must be due to factors other than worker and employer fixed effects.

This in turn suggests a role for time-varying factors, such as specific worker-employer matches and lost specific human capital, in explaining displaced workers' long-term losses.

5.2 Estimated losses by quintile of pre-displacement employer earnings premium

We consider next whether workers displaced from employers offering earnings premiums in the top-quintile experience greater long-term losses than other displaced workers. We also consider whether a greater share of the losses of these displaced workers are due to the loss of employer-specific premiums.

Figure 9 displays the estimated effects of being displaced from an employer whose earnings fixed effect (or premium, $\widehat{\psi}$) was in the top quintile of employers before 2008. (Descriptive statistics for the sample used to obtain these estimates are displayed in columns 5 and 6 of Table 1. The estimates in all three panels of Figure 9 are based on the sample of workers with a pre-2008 employer with top-quintile *earnings* premiums.) Figure 10 displays estimated effects of being displaced from an employer whose earnings fixed effect was in a lower quintile (1 through 4) of employers pre-2008. (The estimates in all three panels of Figure 10 are based on the sample of workers with a pre-2008 employer with lower-quintile *earnings* premiums.)

As before, the red-circle time paths in Figures 9 and 10 show the estimated effects of displacement on log earnings, log hours, and log of the hourly wage rate (from equation (1)); the blue-dot time paths show estimated effects of displacement on employer fixed effects for log earnings, log hours, and log of the hourly wage rate (from equation (4)).

Comparison of Figures 9 and 10 shows that the overall losses of workers displaced from top-quintile employers are somewhat less than those of workers displaced from lower-quintile employers. However, all three panels of Figure 9 show that the share of losses accounted for by

foregone employer fixed effects is substantially greater for workers displaced from top-quintile employers, both at the time of displacement and in the long term. In contrast, Figure 10 shows that essentially none of the losses of workers displaced from lower-quintile employers can be explained by foregone employer fixed effects.

Table 2 (rows E and F) provides details of the estimated losses at quarters 1 and 17–20 after displacement. For workers displaced from top-quintile employers, lost employer premiums explain about 54 percent (–0.067/–0.125) of the earnings loss, 38 percent (–0.021/–0.056) of the reduced hours worked, and 83 percent (–0.046/–0.063) of the reduced wage rate 17–20 quarters after displacement. This compares with 11 percent (–0.017/–0.152) of the earnings loss, 4 percent (–0.003/–0.070) of the reduced hours worked, and 25 percent (–0.020/–0.080) of the reduced wage rate explained by lost employer premiums for workers overall. The importance of employer fixed effects to the losses experienced by workers displaced from top-quintile employers has implications that we pursue in section 6.

5.3 Losses of workers moving to employers offering lower, similar, and higher premiums

It makes sense to explore further the role of employer-specific premiums by examining the time paths of earnings, hours worked, and wage rates for workers who, two years after displacement, worked for an employer whose earnings fixed effect (or premium, $\widehat{\psi}$) was in the same quintile as the pre-displacement employer. We also examine the outcomes of workers who moved to employers whose earnings fixed effect was in a higher or lower quintile than that of the separating employer. This analysis is strictly descriptive because it conditions on an outcome (type of employment two years after displacement). In this sense, it echoes Card, Heining, and

Kline's (2013) event-study analysis, which plots the earnings profiles of workers who move among employers paying similar or different premiums.

Figure 11 displays estimated displacement effects for three groups of workers: those reemployed by an employer whose earnings fixed effect was in the same quintile as the pre-displacement employer's (blue dots), those reemployed by an employer with a lower-quintile earnings fixed effect (red circles), and those reemployed by an employer with a higher-quintile earnings fixed effect (green hollow squares). We use the *earnings* fixed effects to classify displaced workers' changes in employer quintile for all three outcomes—log earnings, log hours, and log hourly wage.

All three groups of displaced workers experience earnings losses and lower wage rates, but the losses are smallest for workers reemployed by an employer with an earnings fixed effect in the same quintile as the pre-displacement employer. Workers reemployed by an employer with a lower earnings fixed effect experience the largest losses, and those reemployed by an employer with a higher earnings fixed effect suffer losses in between those of the other two groups. Also, although work hours recover to nearly their pre-displacement level for all three groups of workers, they recover most quickly for workers reemployed by a same-quintile employer. With respect to wage rates, the long-term losses are close to zero for workers reemployed by a same-quintile employer.

Why do displaced workers reemployed by a higher-quintile fixed effect employer fare worse that those reemployed by a same-quintile fixed effect employer? A reasonable inference from this pattern is that the AKM framework, with additive worker and employer fixed effects, fits displaced workers (i.e., relatively skilled workers with long tenure) less well than it fits workers as a whole. [In Appendix B, we find evidence similar to that in Card, Heining, and Kline

(2013) that the average gain in earnings for those who move to a higher fixed effect employer is symmetric to the average loss in earnings for those who move to a lower fixed effect employer. This suggest that the AKM framework is a good fit for the Washington labor market overall.] The inability of worker and employer fixed effects to more fully explain displaced workers' losses again suggests the importance of other factors, such as lost match effects or specific human capital, in explaining those losses.

5.4 Industry fixed effects

An important literature from the 1980s and 1990s has examined the role of industry of employment in wage determination and motivated much of the subsequent research using linked employer-employee panels (Krueger and Summers 1986, 1988; Dickens and Katz 1986, 1987; Murphy and Topel 1986; Katz and Summers 1989; Groshen 1991; Gibbons and Katz 1992). A central conclusion of this research is that the well-known competitive labor market model does not offer an explanation of large and persistent inter-industry wage differentials, analogous to the conclusion of the AKM literature that the competitive model does not explain persistent within-firm wage differentials.

In this section, we examine the role of the industry from which a worker is displaced, and the loss of industry-specific fixed effects, in explaining displaced workers' earnings losses. The goal is to understand whether the losses we have been attributing to employer fixed effects are in fact the result of the loss of a job in an industry in which policies for earnings, hours, or wage rates are out of the ordinary.

To proceed, we first estimate an AKM-type model, using the full Washington linked employer-employee panel, in which employer fixed effects are replaced by industry fixed effects:

$$\log Y_{ikt} = \alpha_i + \lambda_{k(i,t)} + \theta_t + u_{ikt} \,, \tag{5}$$

where $\lambda_{k(i,t)}$ denotes 102 three-digit NAICS-industry fixed effects, reflecting features of an industry that produce above- or below-average earnings, hours, or wage rates for all workers in industry k. (Other notation is the same as in equation (3).) The function $k(i,t)$ indexes the industry fixed effect for worker i in year t. Estimation of equation (5) for each of the three outcomes produces three vectors of estimated industry fixed effects ($\hat{\lambda}_k$). We use these as dependent variables in equation (4), which produces estimates of changes in earnings, hours, and wage rates attributable to lost industry fixed effects (the δ_ks in equation (4)).

Figure 12 shows the results of this procedure. The red-circle time paths repeat the estimated full displacement effects on log earnings, log hours, and log wage rates (from Figures 2–4), and the blue-dot time paths display the estimated displacement losses attributable to estimated industry fixed effects for the same outcomes. The estimates suggest that lost industry fixed effects play a modest role in the wage rate losses of displaced workers during the two years following displacement (about 1 log point of the full reduction of 10–15 log points), but little role thereafter. Further, foregone industry fixed effects play almost no role in the earnings and hours losses of displaced workers, even near the time of displacement.

The estimates in Figure 12 seem to conflict with the literature cited above showing the importance of industry of employment to wage differentials, and appear at odds with findings showing the importance of lost industry-specific human capital for displaced workers' earnings losses (Kletzer 1989; Neal 1995; Parent 2000). However, the estimated λ_ks from equation (5) are

substantial and widely dispersed, supporting the existence of significant industry-specific premiums.[30] Further, when we estimate displacement effects separately for workers who did and did not return to the 1-digit industry from which they separated, we find that the losses of workers who returned to their pre-displacement industry are about half those of workers who moved to a different industry.[31]

As a result, the estimates in Figure 12 should be interpreted only in the sense that industry fixed effects play little role in displaced workers' losses, not that industry fixed effects are broadly unimportant. In showing that industry fixed effects play little role in displaced workers' losses, they suggest that industry premiums and losses that are correlated with changing industry are correctly attributed to lost industry-specific human capital, rather than to lost industry-wide rents. Also, they tend to reinforce the conclusion that employer fixed effects (and lost rents with respect to earnings and wage rates) play a significant role in displaced workers' losses.

[30] The AKM variance decompositions show that industry fixed effects explain 7 percent of the variation in log earnings, 10 percent of the variation in log hours, and 3 percent of the variation in log wages. Positive sorting of workers to industries explains 7 percent of the variation in log earnings, virtually none of the variation in log hours, and 9 percent of the variation in log wages. (This compares with employer fixed effects explaining 21 percent of the variation in log earnings, 35 percent of the variation in log hours, and 13 percent of the variation in log wages—see Appendix Table B.2.)

[31] Based on employment 8 quarters after displacement, about 49 percent of the displaced workers we examine did not return to their pre-displacement industry. For these workers, the losses appear larger for wage rates than for hours, suggesting lost industry-specific human capital could be a factor in earnings losses. The implication is not strong because whether a worker returns to her pre-displacement industry is endogenous.

6 Discussion and Conclusion

We have attempted to accomplish three objectives: (a) obtain estimates of the long-term earnings losses suffered by workers displaced during the Great Recession using comprehensive UI administrative data; (b) decompose those losses into portions due to fewer hours worked and to reduced hourly wage rates; and (c) estimate the extent to which changes in displaced workers' earnings, work hours, and wage rates can be attributed to fixed unobserved characteristics of the employers that lay off and reemploy those workers.

The estimates are based on quarterly administrative wage records from Washington State during 2002–2014, which are unusual in providing information on quarterly work hours, as well as quarterly earnings, over a 13-year period. Coverage of the wage record is very broad: all UI-covered employers and workers in Washington are included, and each employer's level of employment, payroll, and detailed industry are known.

We take Jacobson, LaLonde, and Sullivan's (1993a, 1993b) well-known approach to estimating the effects of displacement on earnings, and we extend that approach to a decomposition of those earnings losses into components attributable to changed work hours and reduced hourly wage rates. In addition, we estimate employer fixed effects for earnings, work hours, and wage rates using the approach of Abowd, Kramarz, and Margolis (1999), and we use these to estimate the extent to which displaced workers' losses can be attributed to the loss of employer-specific fixed effects.

The main findings are as follows. First, we find that displaced workers experience large and persistent earnings losses. In the quarter after displacement, estimated earnings losses are about 48 percent; in the long-term (that is, 17–20 quarters after displacement), displaced workers' earnings are still about 16 percent less than those of comparable non-displaced workers.

The similarities between these and earlier estimates are perhaps more striking than the differences. They are quite similar to Davis and von Wachter's (2012) estimates of the earnings losses from displacement during several recessions, although they are somewhat smaller than the estimates of Jacobson, LaLonde, and Sullivan (1993a, 1993b) and Couch and Placzek (2010), who were examining the effects of displacement in states that were experiencing the severe contraction of one or more specific industries.

Second, immediately after displacement, about 80 percent of earnings losses are explained by the loss of employment and fewer hours worked. But over time, the relative importance of lost hours falls and the importance of reduced wage rates rises: five years after displacement, about 45 percent of earnings losses can be attributed to reduced work hours, and 55 percent to lower wage rates. The increasing importance of reduced wages with time since displacement reflects the underlying profiles of work hours and wage rates. Whereas work hours drop at the time of displacement, then partially recover (see Figure 3), wage rates drop at the time of displacement and recover only slightly (Figure 4).

Third, for the average displaced worker, stable employer-specific characteristics (fixed effects) account for 11 percent of the long-term earnings losses and about 25 percent of the long-term lower wage rates due to displacement. But for workers displaced from high-premium employers (that is, employers paying earnings premiums in the top quintile), lost employer premiums explain about 54 percent of the long-term earnings losses, 38 percent of the reduced hours worked, and 83 percent of the reduced wage rates five years after displacement. Given that about 60 percent of the displaced workers we observe were displaced from top-quintile

employers, we interpret this as evidence that lost employer rents are an important part of the losses of most displaced workers.[32]

Two significant implications follow from these findings. First, for the average displaced worker, employer fixed effects explain only about 25 percent of long-term wage-rate losses (about 8 log points). This suggests a large role for an unobserved, time-varying job-specific factor, such as lost firm-specific human capital or loss of a favorable specific job-match, in explaining displaced workers' long-term earnings losses (see, e.g., Jung and Kuhn forthcoming). The lost specific human capital interpretation is supported by the finding that displaced workers with short job tenure do not experience long-term wage-rate losses, whereas longer-tenure displaced workers do. The lost job-match interpretation is supported by the finding that displaced workers who are reemployed by a higher fixed-effects employer, do not experience a wage rate gain, as would be implied by the additively separable AKM model; see Card, Heining, and Kline (2013) for a discussion. The data do not allow us to distinguish directly between the lost specific human capital interpretation and the lost job-match interpretation.

The second implication of the findings is that the labor supply of workers displaced in Washington during the Great Recession is quite elastic: the average displaced worker experiences an 8 percent reduction in her hourly wage rate, and a 7 percent reduction in work hours. The interpretation of these estimates as a labor supply effect is supported by the finding that employer-specific policies regarding hours worked (employer fixed effects for hours) play a minor role in explaining displaced workers' reduced work hours.

[32] Our findings differ from Fackler et al. (2017) who find that (i) the losses of displaced workers in Germany are negligible and (ii) almost entirely explained by the loss of employer effects. However, Fackler et al. (2017) study displacement due to employer bankruptcy, a special case that complicates direct comparison. In a related paper, Fackler et al. (2016, p. 128) argue, that from the worker's perspective, mass layoffs (defined as a thirty percent drop the employer workforce for employers employing more than 50 workers) are a better proxy for unanticipated exogenous separation shocks than are employer bankruptcies.

The findings have some unusually clear implications for policy. First, for the average displaced worker, earnings losses can be attributed mainly to either lost firm-specific human capital or the loss of a favorable job match. For these workers, effective reemployment services are a logical policy approach because of the need either to reestablish a favorable job match or to become reemployed and start re-accumulating specific human capital. Second, for workers displaced from employers who paid premium earnings and wage rates, a wage-rate subsidy is a reasonable alternative because it would both compensate displaced workers for their loss and act to offset their reduced labor supply (Davidson and Woodbury 2000). Retraining is a relatively unattractive alternative, given the lack of evidence that deficient general human capital is at the root of displaced workers earnings losses. In fact, the importance of employer fixed effects in explaining the losses of the 60 percent of workers who were displaced from an employer paying a top-quintile earning premium provides a possible explanation for the limited effectiveness of retraining in improving the earnings of displaced workers.

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Table 1
Sample descriptive statistics

	(1)	(2)	(3)	(4)	(5)	(6)
	All workers		Workers outside NAICS industries 51–56		Workers employed by top-quintile employers	
	Displaced	Non-displaced	Displaced	Non-displaced	Displaced	Non-displaced
Quarterly average earnings, hours, and wage rates, 2002–2005						
Earnings ($)	13,739	12,482	12,417	12,135	15,759	16,243
	(6,668)	(5,996)	(6,215)	(5,490)	(6,457)	(6,042)
Paid work hours	518	500	508	500	537	514
	(80)	(95)	(85)	(97)	(64)	(84)
Hourly wage rate ($/hours)	64.41	51.22	52.68	49.49	75.15	65.23
	(44.45)	(38.96)	(38.66)	(37.69)	(44.94)	(39.54)
Worker characteristics, 2007:IV						
Female (proportion)	0.300	0.359	0.274	0.353	0.240	0.230
Race (proportions)						
White, not Hispanic	0.774	0.677	0.736	0.671	0.813	0.739
Black, not Hispanic	0.031	0.033	0.030	0.032	0.022	0.034
Hispanic	0.074	0.133	0.105	0.139	0.043	0.058
Asian/Pacific Islander	0.071	0.100	0.078	0.100	0.068	0.109
American Indian or Alaskan Native	0.014	0.014	0.015	0.015	0.012	0.011
Missing, unknown, or not available	0.037	0.044	0.035	0.044	0.042	0.050
Schooling (proportions)						
less than high school	0.079	0.129	0.111	0.135	0.053	0.062
GED	0.031	0.032	0.038	0.033	0.022	0.035
high school graduate	0.446	0.462	0.469	0.472	0.461	0.496
some college	0.153	0.161	0.151	0.158	0.134	0.183
associate's degree	0.125	0.101	0.121	0.102	0.125	0.108
bachelors degree	0.135	0.093	0.095	0.081	0.161	0.093
master's/PhD	0.030	0.023	0.016	0.019	0.043	0.022
Age (years)	39.68	41.47	39.01	41.53	40.53	41.87
	(6.39)	(6.44)	(6.53)	(6.44)	(5.90)	(6.20)
Employer characteristics in 2007:IV						
Employer size (number of workers)	2,097	8,478	824	8,400	2,881	16,622
	(2,562)	(20,065)	(1,550)	(20,317)	(2,694)	(28,378)
NAICS Industry (proportions)						
11 agriculture, forestry, fishing	0.014	0.045	0.024	0.048	0.001	0.002
21–23 mining, utilities, construction	0.078	0.082	0.132	0.087	0.097	0.153
31–33 manufacturing	0.268	0.460	0.455	0.491	0.274	0.631
42–49 trade, transportation	0.152	0.145	0.258	0.155	0.035	0.058
51–56 information, finance, prof. services	0.411	0.063	n/a	n/a	0.589	0.103
61–62 educational and health care services	0.013	0.093	0.021	0.099	0.003	0.024
71–72 arts, recreation, hospitality services	0.051	0.032	0.087	0.034	n/a	0.000
81 other services	0.007	0.006	0.011	0.006	0.001	0.002
92–99 public administration and unclassified	0.007	0.075	0.012	0.080	0.001	0.028
Number of employers (pre- and post-displacement)	3,621	1,570	513	1,383	195	447
Number of workers	3,032	13,290	1,786	12,447	1,802	5,621

Notes : Earnings are expressed in constant 2010 dollars. Standard deviations are in parentheses.
Source: Authors' tabulations of Washington administrative wage and claims records. See section 2.1 for details of the sample construction.

Table 2
Summary of estimated losses due to displacement

	Earnings		Hours		Hourly wage rate	
	Q1	Q17-Q20	Q1	Q17-Q20	Q1	Q17-Q20
All workers						
A. Full losses						
levels	–$5,964	–$1,941	–200	–29.3	–1.89	–1.46
	(–47.8%)	(–15.6%)	(–40.0%)	(–5.9%)	(–3.7%)	(–2.9%)
logs	–0.488	–0.152	–0.384	–0.070	–0.109	–0.080
B. Losses attributable to foregone employer fixed effects						
logs	–0.032	–0.017	–0.015	0.003	–0.017	–0.020
Workers by industry group						
C. Full losses, all workers except NAICS 51–56						
logs	–0.595	–0.206	–0.425	–0.098	–0.172	–0.110
D. Full losses, NAICS 51–56 workers only						
logs	–0.363	–0.172	–0.384	–0.065	–0.072†	–0.112
Workers displaced from employers paying top-quintile earnings premiums						
E. Full losses						
logs	–0.368	–0.125	–0.303	–0.056	–0.074	–0.063
F. Losses attributable to foregone employer fixed effects						
logs	–0.074	–0.067	–0.038	–0.021	–0.036	–0.046

Note: Each entry gives the estimated displacement effect on the indicated outcome in either quarter 1 (Q1) or the average of quarters 17, 18, 19, and 20 (Q17-Q20) following displacement. For levels, implied percentage changes relative to the non-displaced comparison group are shown in parentheses. (For example, the estimated effect of displacement on avearge earnings in quarters 17–20 after displacement is –$1,941, which is 15.6% less than the earnings of the non-displaced comparison group.)

†Average of Q1 and Q2.

Table 3: Estimated earnings losses due to displacement, selected studies using UI administrative records

Study	State and time period	Sample	Earnings losses in the first year	Earnings losses after five years
Jacobson, Lalonde, and Sullivan (1993b)	Pennsylvania, 1974–1986	All UI claimants	$7,800 (66%*)	$2,900 or (24%*)
Couch and Placzek (2010)	Connecticut, 1993–2004	All UI claimants	$7,700 (49%)	$5,100 (32%)
Lachowska, Mas, and Woodbury (2017)	Washington, 2002–2014	All UI claimants	$5,960 or 48 percent (=$5,960/$12,482)	$1,940 (16%)

Sources: Estimates from the papers cited.

*Percentage estimates for Jacobson, LaLonde, and Sullivan (1993b) are reported in Couch and Placzek (2010), Table 1.

Table 4

Estimated displacement effects on the distribution on average weekly work hours

Quarter relative to displacement	Outcome								
	Hours > 0	Hours > 10	Hours > 20	Hours > 30	Hours > 35	Hours > 40	Hours > 45	Hours > 50	Hours > 60
0	-0.065	-0.154	-0.253	-0.360	-0.372	-0.276	-0.057	-0.001	0.005
	(0.005)	(0.007)	(0.009)	(0.010)	(0.010)	(0.009)	(0.007)	(0.005)	(0.002)
1	-0.228	-0.287	-0.346	-0.442	-0.513	-0.291	-0.086	-0.017	0.004
	(0.008)	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)	(0.006)	(0.004)	(0.002)
2	-0.139	-0.195	-0.248	-0.277	-0.240	-0.210	-0.057	-0.005	0.007
	(0.007)	(0.008)	(0.009)	(0.010)	(0.010)	(0.010)	(0.007)	(0.005)	(0.002)
3	-0.108	-0.158	-0.198	-0.219	-0.166	-0.086	-0.061	-0.011	0.006
	(0.006)	(0.008)	(0.009)	(0.010)	(0.010)	(0.010)	(0.007)	(0.004)	(0.002)
4	-0.095	-0.148	-0.192	-0.196	-0.207	-0.161	-0.040	-0.001	0.009
	(0.006)	(0.007)	(0.008)	(0.009)	(0.010)	(0.010)	(0.007)	(0.005)	(0.002)
5	-0.081	-0.118	-0.155	-0.145	-0.110	-0.089	-0.014	0.013	0.011
	(0.006)	(0.007)	(0.008)	(0.009)	(0.010)	(0.010)	(0.007)	(0.005)	(0.002)
6	-0.052	-0.077	-0.111	-0.123	-0.107	-0.112	-0.031	0.002	0.010
	(0.005)	(0.006)	(0.007)	(0.009)	(0.010)	(0.010)	(0.007)	(0.005)	(0.002)
7	-0.037	-0.068	-0.100	-0.105	-0.101	-0.127	-0.042	0.001	0.009
	(0.005)	(0.006)	(0.007)	(0.009)	(0.010)	(0.010)	(0.007)	(0.005)	(0.002)
8	-0.038	-0.064	-0.098	-0.114	-0.094	-0.107	-0.034	0.002	0.010
	(0.005)	(0.006)	(0.007)	(0.009)	(0.010)	(0.010)	(0.007)	(0.005)	(0.002)
9	-0.032	-0.058	-0.085	-0.105	-0.111	-0.063	-0.007	0.013	0.012
	(0.004)	(0.006)	(0.007)	(0.008)	(0.010)	(0.010)	(0.008)	(0.006)	(0.003)
10	-0.033	-0.052	-0.076	-0.092	-0.102	-0.065	-0.026	-0.000	0.008
	(0.004)	(0.006)	(0.007)	(0.008)	(0.010)	(0.011)	(0.008)	(0.005)	(0.003)
11	-0.032	-0.044	-0.077	-0.112	-0.101	-0.072	-0.028	0.008	0.007
	(0.004)	(0.005)	(0.007)	(0.008)	(0.009)	(0.011)	(0.008)	(0.006)	(0.002)
12	-0.033	-0.061	-0.096	-0.110	-0.091	-0.019	0.024	0.029	0.012
	(0.004)	(0.006)	(0.007)	(0.008)	(0.009)	(0.011)	(0.008)	(0.006)	(0.003)
13	-0.028	-0.051	-0.080	-0.111	-0.121	-0.084	-0.015	0.020	0.018
	(0.004)	(0.005)	(0.007)	(0.008)	(0.009)	(0.011)	(0.008)	(0.006)	(0.003)
14	-0.034	-0.061	-0.086	-0.095	-0.072	-0.015	0.015	0.026	0.008
	(0.004)	(0.006)	(0.007)	(0.008)	(0.009)	(0.011)	(0.008)	(0.006)	(0.003)
15	-0.026	-0.047	-0.074	-0.096	-0.096	-0.084	-0.013	0.012	0.011
	(0.004)	(0.005)	(0.007)	(0.008)	(0.009)	(0.011)	(0.008)	(0.006)	(0.003)
16	-0.027	-0.051	-0.086	-0.093	-0.077	-0.020	0.010	0.017	0.006
	(0.004)	(0.005)	(0.007)	(0.008)	(0.009)	(0.011)	(0.008)	(0.006)	(0.003)
17	-0.026	-0.047	-0.074	-0.080	-0.087	-0.057	0.002	0.022	0.020
	(0.004)	(0.005)	(0.006)	(0.008)	(0.009)	(0.011)	(0.008)	(0.006)	(0.003)
18	-0.026	-0.048	-0.062	-0.066	-0.065	-0.028	0.023	0.028	0.012
	(0.004)	(0.005)	(0.006)	(0.008)	(0.009)	(0.011)	(0.009)	(0.006)	(0.003)
19	-0.022	-0.037	-0.056	-0.073	-0.089	-0.085	-0.028	0.008	0.018
	(0.004)	(0.005)	(0.006)	(0.008)	(0.010)	(0.011)	(0.009)	(0.006)	(0.003)
20	-0.017	-0.040	-0.075	-0.085	-0.084	-0.054	-0.008	0.015	0.008
	(0.004)	(0.005)	(0.007)	(0.008)	(0.010)	(0.012)	(0.009)	(0.006)	(0.003)
Comparison group mean	0.996	0.980	0.952	0.867	0.758	0.457	0.207	0.095	0.022
Worker-quarter observations	826,219	826,219	826,219	826,219	826,219	826,219	826,219	826,219	826,219
Number of workers	16,322	16,322	16,322	16,322	16,322	16,322	16,322	16,322	16,322

Notes: Each column shows estimated changes in the probability of working at least a given number of weekly hours (on average over a quarter), based on estimates of equation (1). For example, the column headed "Hours > 35" is based on equation (1) with an indicator of whether the worker's weekly hours exceeded 35 as the dependent variable. Standard errors clustered by worker are shown in parentheses.

Table 5

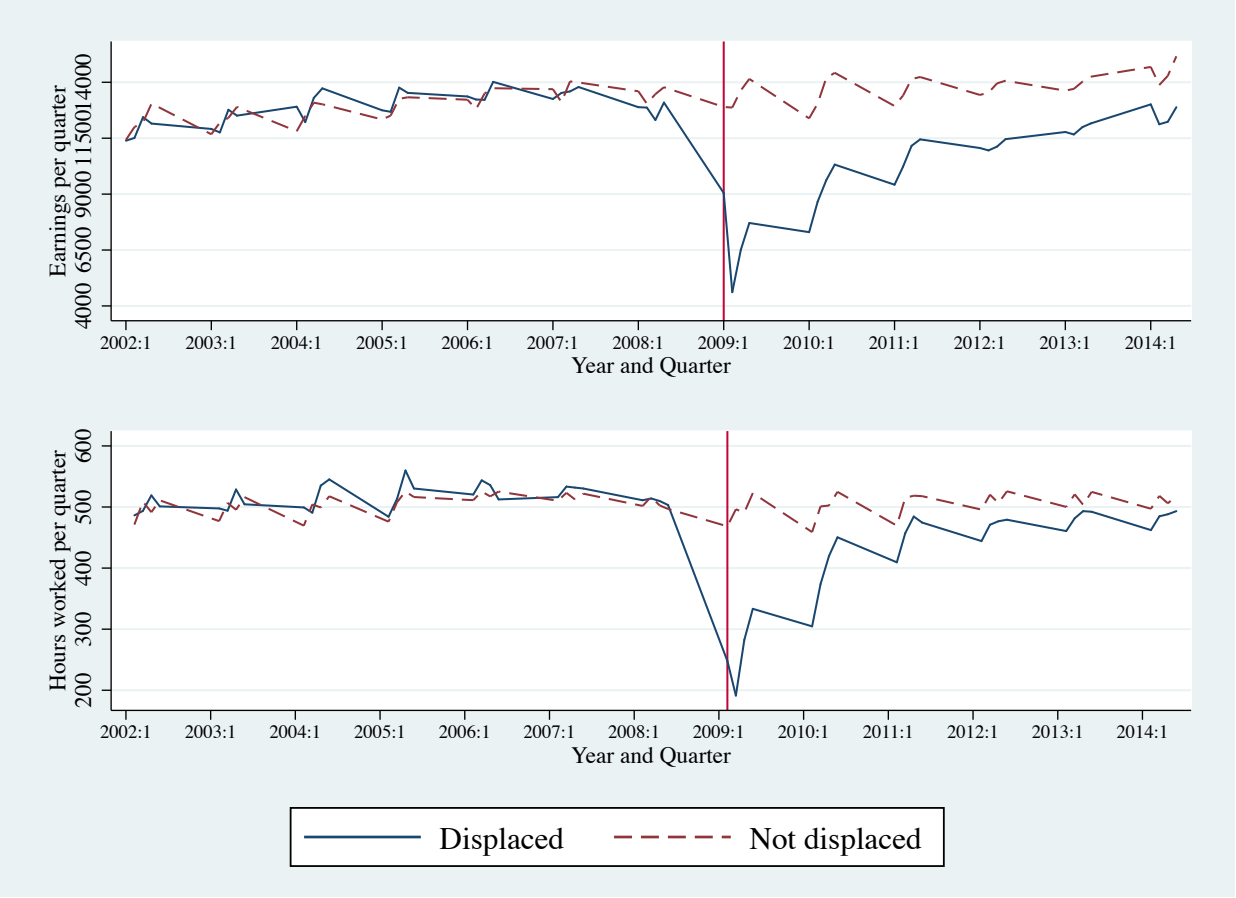
Estimated displacement effects on log earnings, log hours, log wages, and AKM employer fixed effects (ψ)

	Log earnings	ψ log earnings	Log hours	ψ log hours	Log wage	ψ log wage
Quarter relative to displacement	(1)	(2)	(3)	(4)	(5)	(6)
0	-0.36***	0.00*	-0.40***	0.00***	0.06***	-0.00
	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
1	-0.49***	-0.03***	-0.38***	-0.01***	-0.11***	-0.02***
	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
2	-0.39***	-0.03***	-0.25***	-0.01***	-0.15***	-0.02***
	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
3	-0.31***	-0.03***	-0.20***	-0.01***	-0.12***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
4	-0.32***	-0.03***	-0.22***	-0.01***	-0.11***	-0.02***
	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
5	-0.26***	-0.03***	-0.13***	-0.01***	-0.13***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
6	-0.23***	-0.02***	-0.11***	-0.01**	-0.11***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
7	-0.24***	-0.02***	-0.13***	-0.01***	-0.11***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
8	-0.23***	-0.02***	-0.11***	-0.01**	-0.12***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
9	-0.22***	-0.02***	-0.11***	-0.01**	-0.11***	-0.01***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
10	-0.19***	-0.02***	-0.09***	-0.00	-0.09***	-0.01***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
11	-0.22***	-0.01***	-0.09***	0.00	-0.12***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
12	-0.18***	-0.01***	-0.09***	0.01**	-0.09***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
13	-0.19***	-0.01***	-0.09***	0.01*	-0.10***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
14	-0.15***	-0.01***	-0.08***	0.01**	-0.07***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
15	-0.18***	-0.01**	-0.08***	0.01**	-0.09***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
16	-0.17***	-0.01***	-0.08***	0.01**	-0.09***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
17	-0.17***	-0.01***	-0.08***	0.01*	-0.09***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
18	-0.13***	-0.02***	-0.05***	0.00	-0.07***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
19	-0.16***	-0.02***	-0.06***	0.00	-0.09***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
20	-0.15***	-0.02***	-0.08***	0.00	-0.07***	-0.02***
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Number of worker-quarters	822,933	822,279	819,241	822,279	819,233	822,279
Number of workers	16,322	16,322	16,322	16,322	16,322	16,322
R^2	0.083	0.030	0.054	0.019	0.066	0.029

Notes: Estimates in columns (1), (3), and (5) are based on equation (1) and are graphed in Figures 2, 3, and 4. Estimates in columns (2), (4), and (6) are based on equation (4) and are graphed in Figure 10. For brevity, estimated coefficients for quarters –20 to –1 relative to displacement are not displayed. Each regression also controls for a worker-specific fixed effect; a vector of quarterly dummies; worker's age and age squared; a vector of gender, race, and education dummies interacted with the worker's age; logarithm of pre-displacement employer size and 1-digit NAICS code in 2007:IV interacted with a vector of yearly dummies; a simple average of pre-displacement earnings with the primary employer and an average of pre-displacement hours with the primary employer, each interacted with a vector of yearly dummies. Earnings are expressed in constant 2010 dollars.

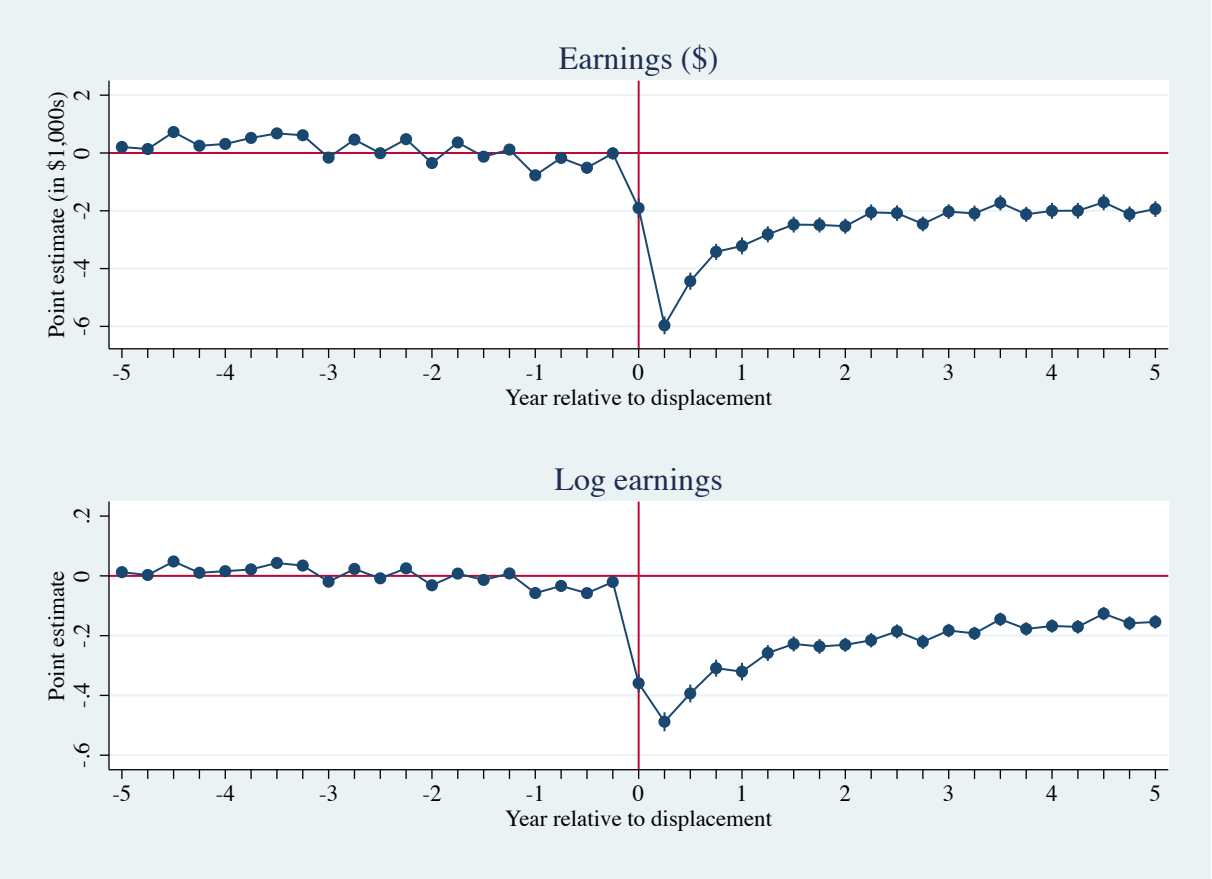
Standard errors clustered by worker in parentheses (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$).

Figure 1
Earnings (top) and hours (bottom) profiles of displaced and non-displaced workers



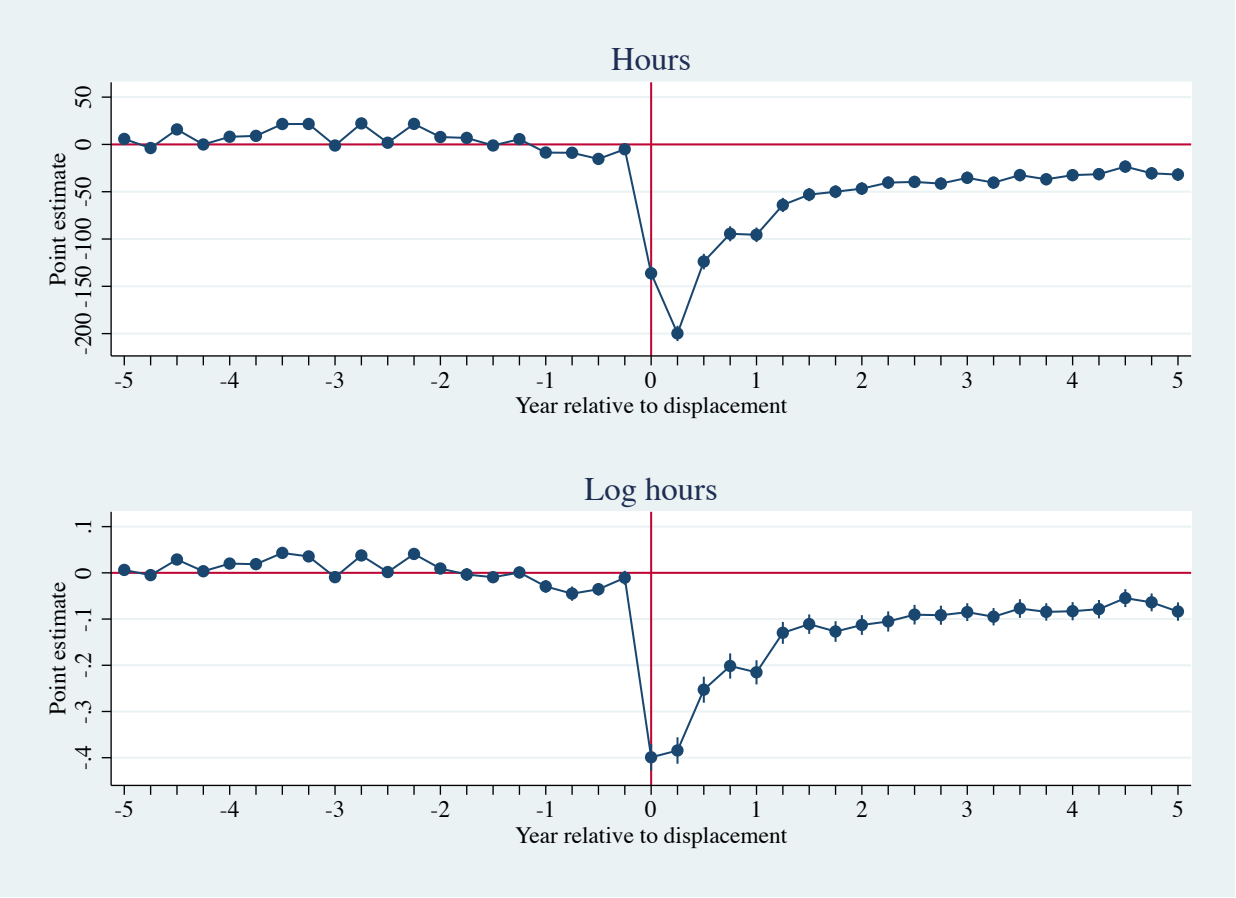
Notes: The top figure shows the quarterly earnings profiles (constant 2010 dollars) of workers displaced in Washington during the first quarter of 2009 (solid blue line) and the non-displaced comparison group (dashed red line). The bottom figure shows the work hour profiles of the same two groups. Both earnings and hours are unconditional (that is, include observations of zero earnings and hours). The vertical lines denote the quarter of separation.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1, 4.1, and 4.2 of the text for details.

Figure 2
Estimated earnings losses due to displacement, Washington, 2008–2010



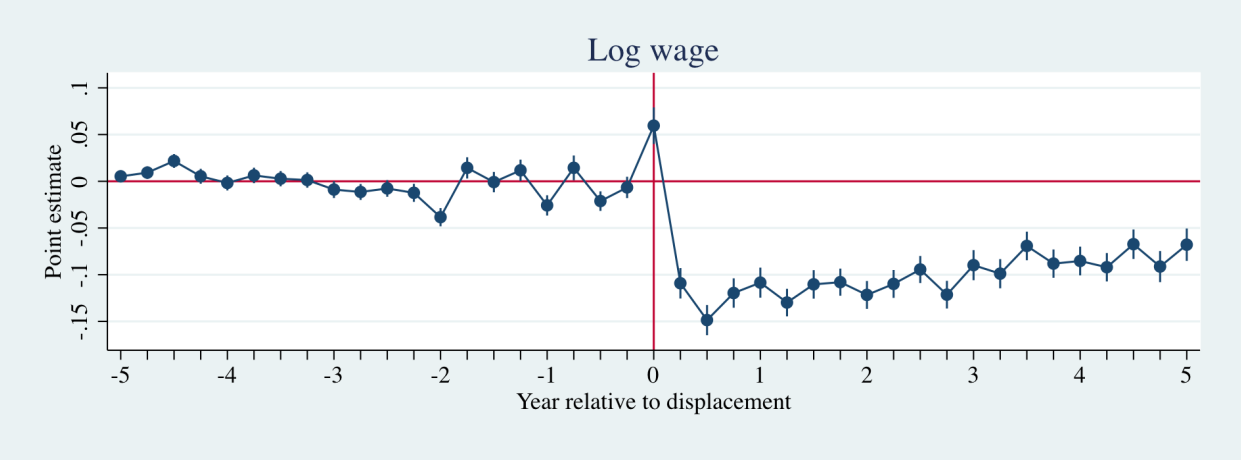
Notes: The top figure shows estimated δ_ks—quarterly unconditional earnings lost due to displacement (in constant 2010 $1,000s)—based on equation (1) with unconditional earnings from the primary employer as the dependent variable. The bottom figure shows estimated δ_ks—logarithm of quarterly earnings lost due to displacement—based on equation (1) with the log of earnings from the primary employer as the dependent variable. Whiskers (which are very small) denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1, 4.1, and 4.2 of the text for details.

Figure 3
Estimated work hour losses due to displacement, Washington, 2008–2010



Notes: The top figure shows estimated δ_ks—quarterly unconditional hours lost due to displacement—based on equation (1) with unconditional hours at the primary employer as the dependent variable. The bottom figure shows estimated δ_ks—logarithm of quarterly hours lost due to displacement—based on equation (1) with the log of hours at the primary employer as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1, 4.1, and 4.2 of the text for details.

Figure 4
Estimated hourly wage rate losses due to displacement, Washington, 2008–2010

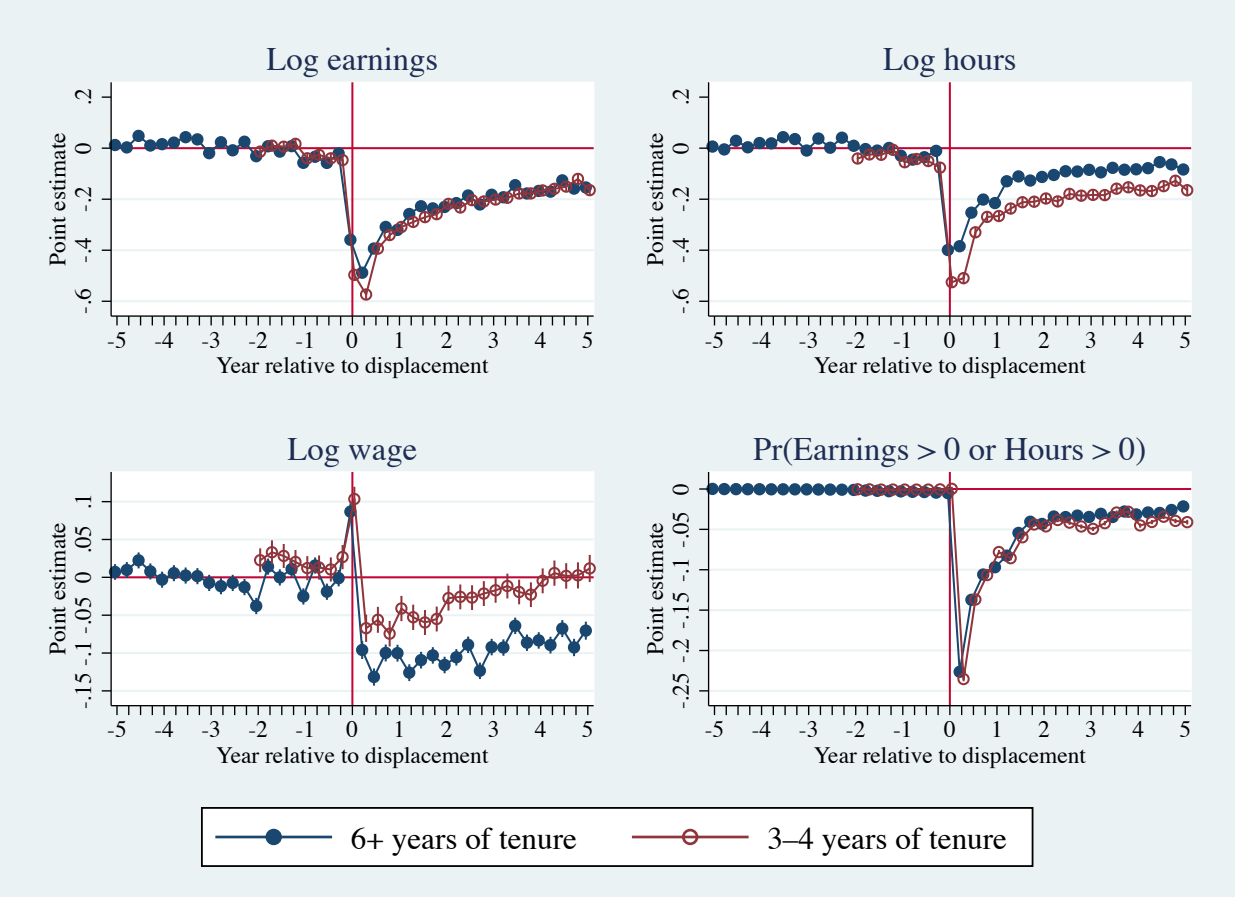


Notes: The figure shows estimated δ_ks—the reduction in the log hourly wage rate due to displacement—based on equation (1) with the log of hourly wage rate at the primary employer (constant 2010 dollars per hour) as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1, 4.1, and 4.2 of the text for details.

Figure 5
Estimated displacement effects for workers displaced from industries other than NAICS industries 51–56

Notes: The figures show estimated displacement effects for workers displaced from any industry *except* NAICS industries 51–56 (information, finance and insurance, real estate, professional, scientific, and technical services, management of companies; administrative, support, and waste management and remediation services). Each figure shows the profile of displacement effects for an outcome—log quarterly earnings, log quarterly hours, and log wage rate (all from the primary employer), or the probability of employment (positive earnings or hours)—based on estimates of δ_k in equation (1). Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See section 3.1 and 4.4 of the text for details.

Figure 6
Estimated displacement effects by job tenure at time of displacement

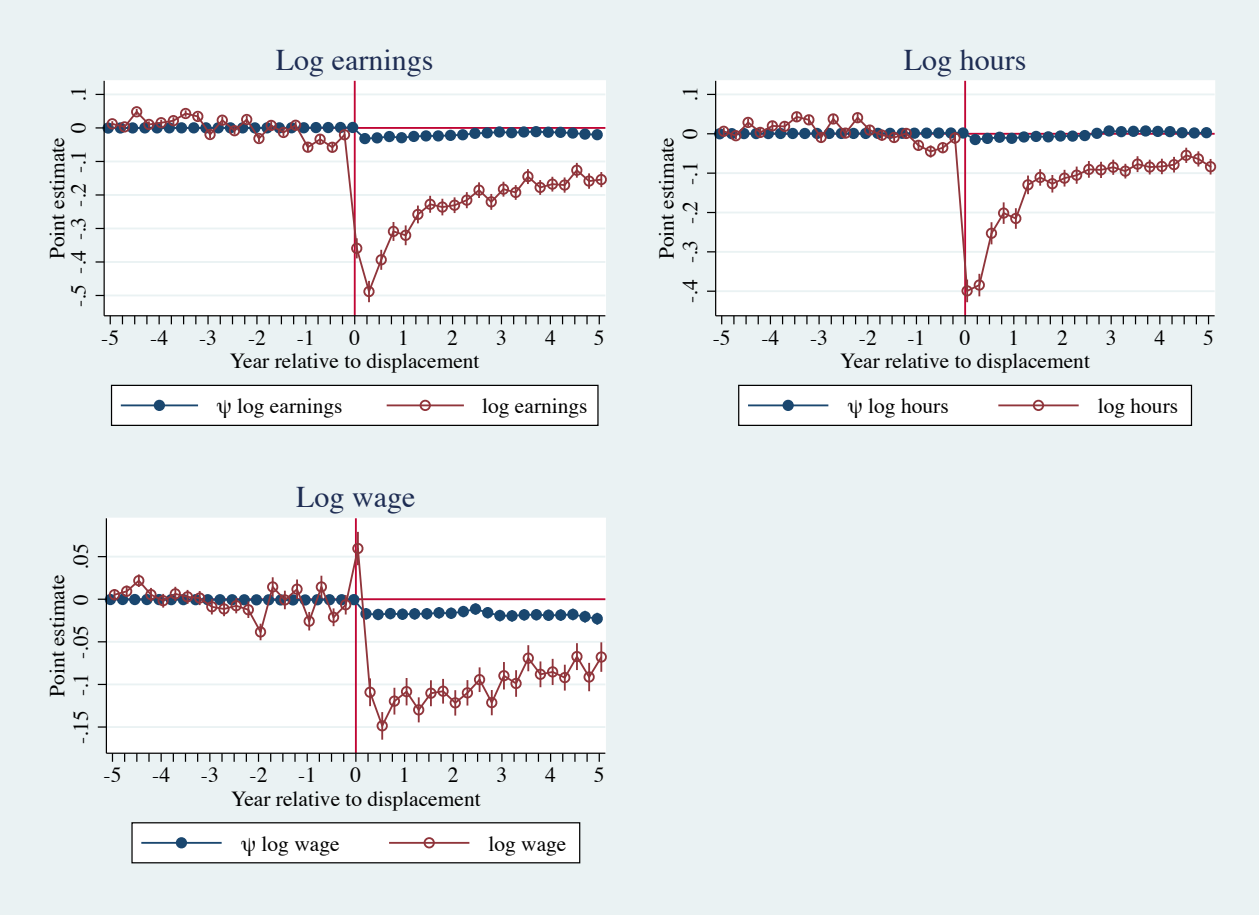


Notes: The figures show estimated displacement effects for workers with 3–4 years of job tenure at the time of displacement (red circles), and 6 or more years of job tenure at the time of displacement (blue dots, repeated from Figures 2, 3, 4 for the first three panels). The omitted (reference) time period for workers displaced with 3–4 years of tenure (and their comparison group) is 3 years before displacement. Each figure shows the profile of displacement effects for an outcome—quarterly log earnings, log hours, log wage rate (all from the primary employer), or the probability of employment (positive earnings or hours)—based on estimates of δ_k in equation (1). Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1 and 4.4 of the text for details.

Figure 7
Estimated displacement effects for workers less strongly attached to the labor force

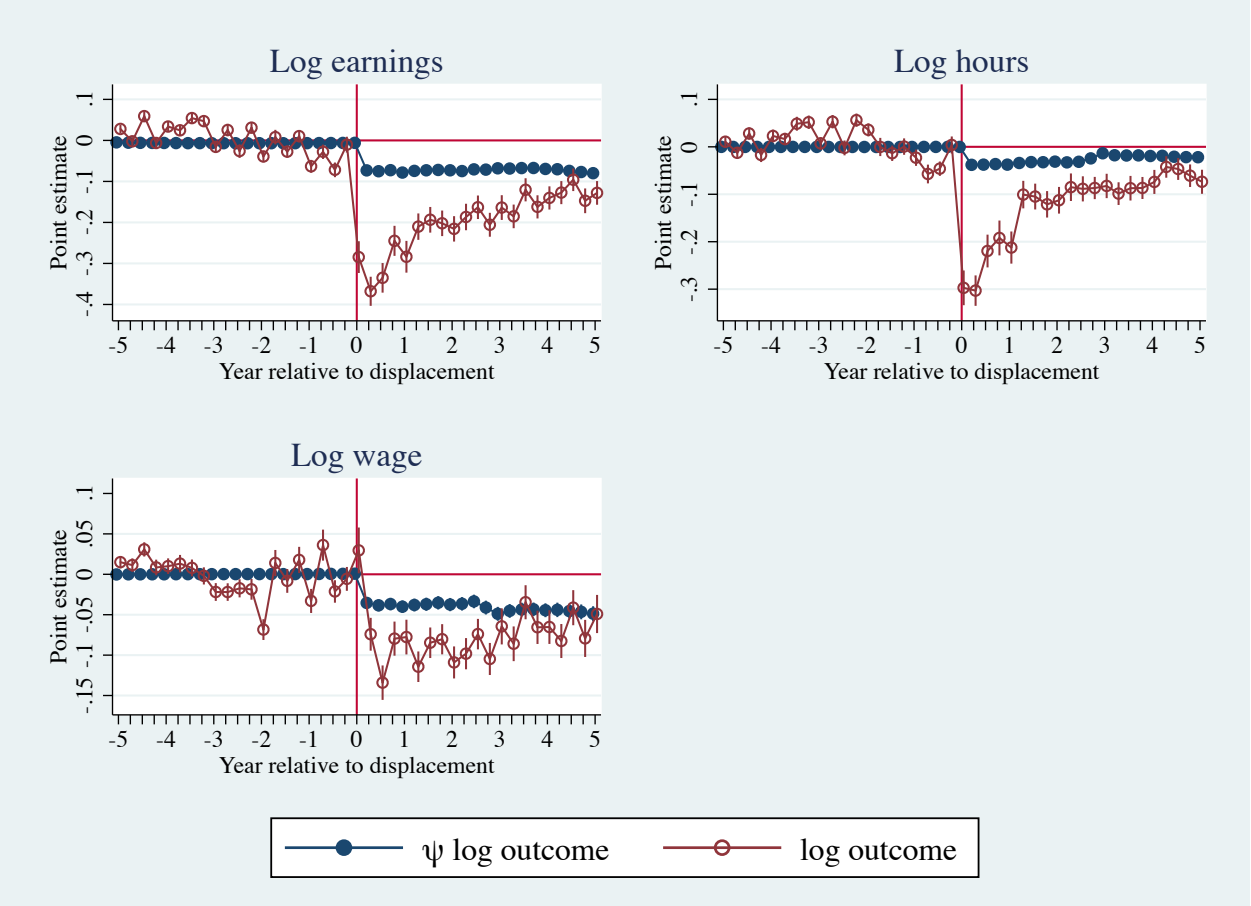
Notes: The figures show estimated displacement effects for a sample of displaced workers not required to be observed with positive earnings or hours after being displaced (blue dots), and for the sample used in Figures 2, 3, and 4 (observed with positive earnings or hours in at least one quarter of each year following displacement—red circles, repeated from Figures 2, 3, and 4). The whiskers denote 95–percent confidence intervals clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1 and 4.5 of the text for details.

Figure 8
Estimated displacement losses due to foregone employer fixed effects



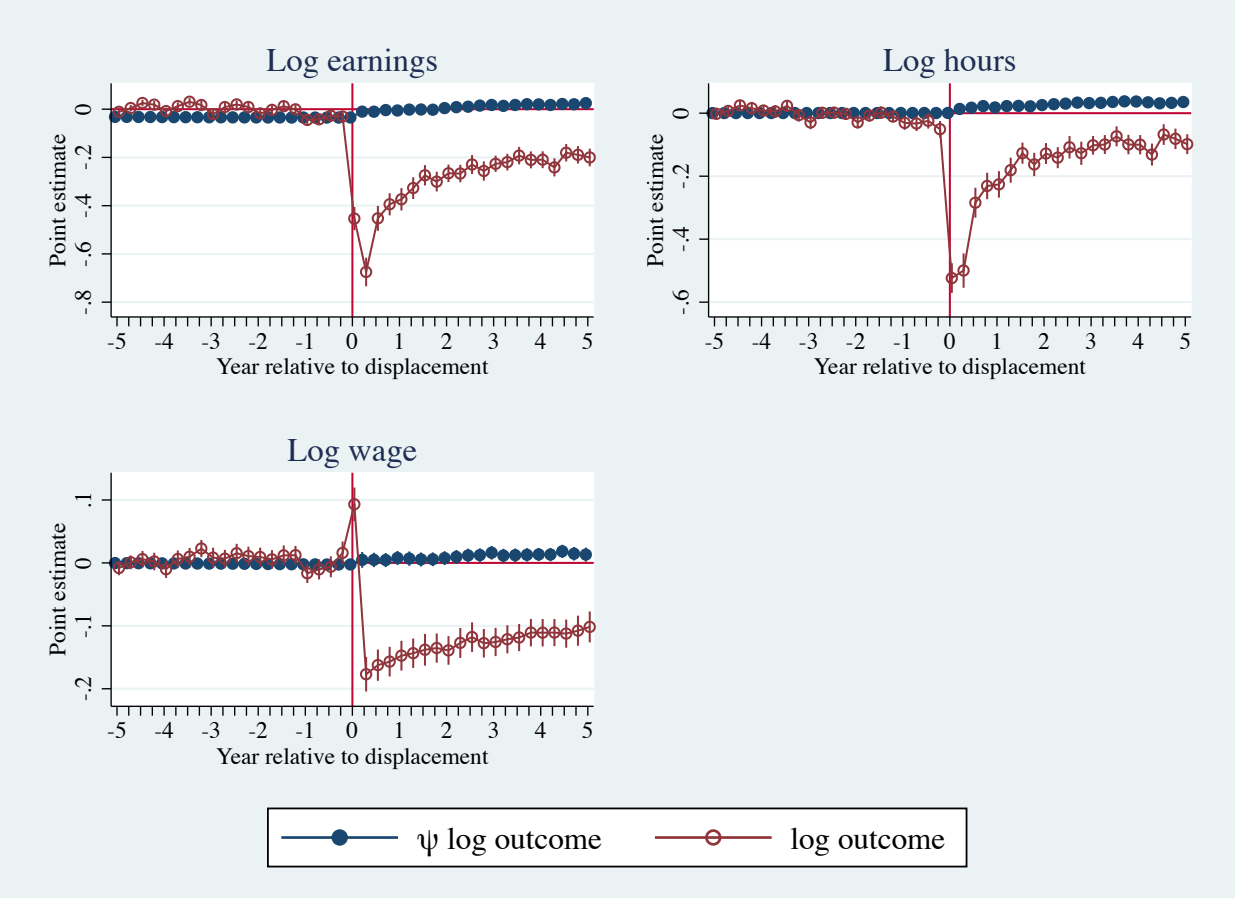
Notes: The figures show estimated displacement losses attributable to foregone employer fixed effects (blue dots) compared with the full losses due to displacement (red circles, repeated from Figures 2, 3, and 4). Losses attributable to foregone employer fixed effects are estimates of δ_k from equation (4). For example, to obtain the estimates of earnings lost due to foregone employer premiums, equation (4) was estimated with the AKM employer fixed effect ($\widehat{\psi}$) for log earnings as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.2 and 5.1 of the text for details.

Figure 9
Estimated displacement losses due to foregone employer fixed effects for workers displaced from employers paying top-quintile earnings premiums



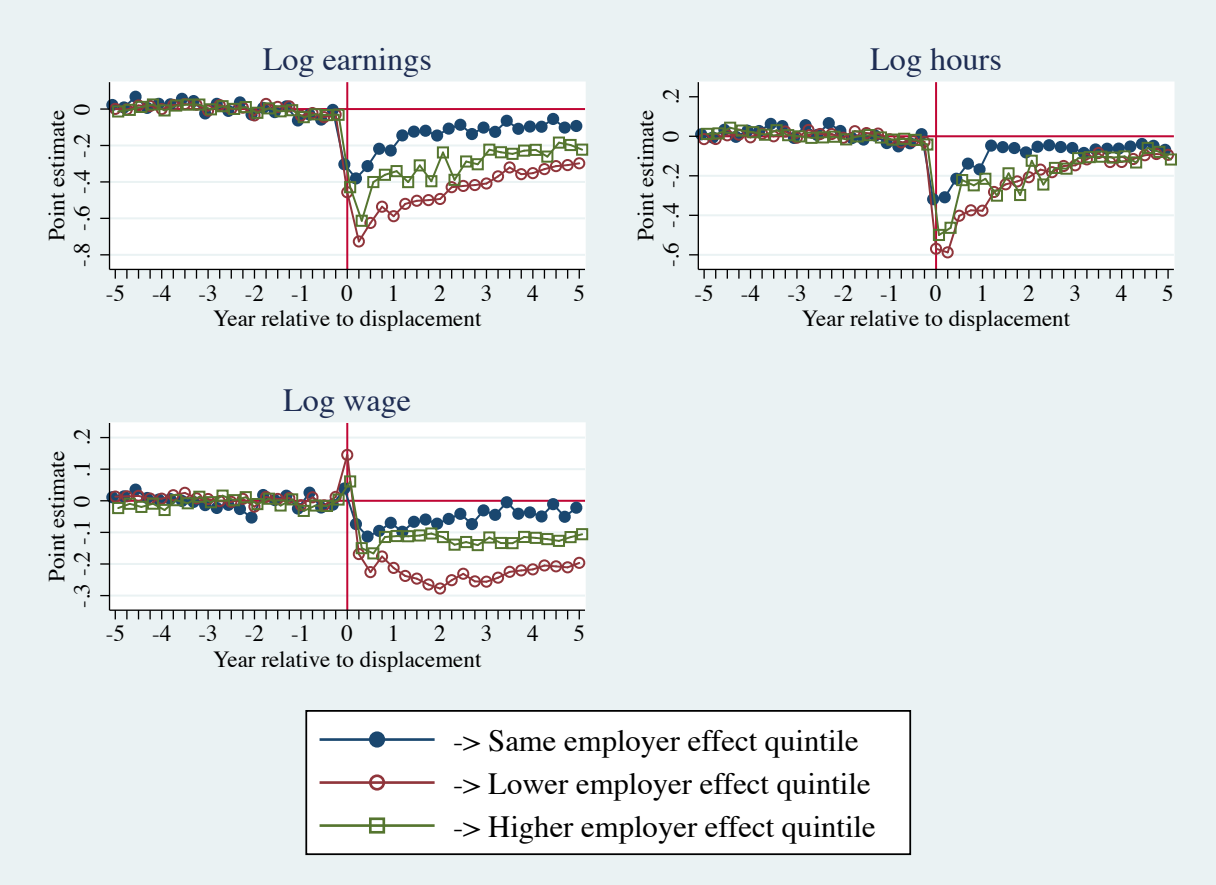
Notes: The figures show estimated displacement losses attributable to foregone employer fixed effects (blue dots, estimated from equation (4)), and full losses due to displacement (red circles, estimated from equation (1)), for workers displaced from employers paying top-quintile earnings premiums (60 percent of displaced workers in the sample—see columns 5 and 6 of Table 1). Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.2 and 5.2 of the text for details.

Figure 10
Estimated displacement losses due to foregone employer fixed effects for workers displaced from employers paying earnings premiums below the top quintile



Notes: The figures show estimated displacement losses attributable to foregone employer premiums (solid blue dots, estimated from equation (4)), and full losses due to displacement (red circles, estimated from equation (1)) and for workers displaced from employers paying an earnings premium below the top quintile (40 percent of displaced workers in the sample). Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.2 and 5.2 of the text for details.

Figure 11
Losses of displaced workers who moved to employers paying the same, lower, and higher earnings premiums compared with the separating employer



Notes: The figures show the losses of displaced workers who, eight quarters after separation, were reemployed by an employer paying an earnings premium in the same quintile as the separating employer (blue dots, 65.1 percent of the sample), by an employer paying a lower-quintile earnings premium than the separating employer (red circles, 18.4 percent of the sample), and by an employer paying a higher-quintile earnings premium than the separating employer (green squares, 16.5 percent of the sample). Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.2 and 5.3 of the text for details.

Figure 12
Estimated displacement losses due to foregone industry fixed effects

Notes: The figures show estimated displacement losses attributable to foregone industry fixed effects (blue dots) compared with the full losses due to displacement (red circles). For example, to obtain the estimates of lost earnings due to foregone industry fixed effects, equation (4) was estimated with the AKM industry fixed effect ($\hat{\lambda}_k$) for log earnings as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See section 5.4 of the text for details.

Sources of Displaced Workers' Long-Term Earnings Losses: Appendices

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December 31, 2017

Appendix A: Additional tables and figures

Appendix B: Estimation of employer fixed effects for earnings, hours, and wage rates

Appendix C: Estimates using an alternative comparison group

Appendix A: Additional tables and figures

Appendix Table A.1
Estimated effects of displacement on unconditional earnings and log earnings (from primary employer and all employers)

Outcome variable	Earnings (in $1,000s)	All earnings (in $1,000s)	Log earnings	Log all earnings
	(1)	(2)	(3)	(4)
Covariates				
Quarter since displacement				
–20	0.21***	0.21***	0.01***	0.01***
	(0.06)	(0.06)	(0.00)	(0.00)
–19	0.14**	0.14**	0.00	0.00
	(0.06)	(0.06)	(0.00)	(0.00)
–18	0.72***	0.73***	0.05***	0.05***
	(0.07)	(0.07)	(0.00)	(0.00)
–17	0.25***	0.25***	0.01**	0.01**
	(0.07)	(0.07)	(0.00)	(0.00)
–16	0.31***	0.31***	0.02***	0.02***
	(0.07)	(0.07)	(0.00)	(0.00)
–15	0.52***	0.53***	0.02***	0.02***
	(0.08)	(0.09)	(0.01)	(0.01)
–14	0.68***	0.68***	0.04***	0.04***
	(0.08)	(0.08)	(0.00)	(0.00)
–13	0.61***	0.61***	0.03***	0.03***
	(0.08)	(0.08)	(0.01)	(0.01)
–12	-0.16**	-0.16**	-0.02***	-0.02***
	(0.08)	(0.08)	(0.01)	(0.01)
–11	0.46***	0.47***	0.02***	0.02***
	(0.09)	(0.09)	(0.01)	(0.01)
–10	-0.01	0.01	-0.01	-0.01
	(0.08)	(0.08)	(0.01)	(0.01)
–9	0.48***	0.49***	0.03***	0.03***
	(0.08)	(0.09)	(0.01)	(0.01)
–8	-0.35***	-0.34***	-0.03***	-0.03***
	(0.08)	(0.08)	(0.01)	(0.01)
–7	0.36***	0.38***	0.01	0.01
	(0.09)	(0.09)	(0.01)	(0.01)
–6	-0.13	-0.11	-0.01**	-0.01**
	(0.09)	(0.09)	(0.01)	(0.01)
–5	0.12	0.14	0.01	0.01*
	(0.09)	(0.09)	(0.01)	(0.01)
–4	-0.77***	-0.75***	-0.06***	-0.05***
	(0.09)	(0.09)	(0.01)	(0.01)
–3	-0.17*	-0.14	-0.03***	-0.03***
	(0.10)	(0.10)	(0.01)	(0.01)
–2	-0.51***	-0.49***	-0.06***	-0.05***
	(0.10)	(0.10)	(0.01)	(0.01)
–1	-0.01	0.03	-0.02***	-0.01*
	(0.11)	(0.11)	(0.01)	(0.01)
0	-1.91***	-0.94***	-0.36***	-0.27***
	(0.17)	(0.18)	(0.02)	(0.02)
1	-5.96***	-5.16***	-0.49***	-0.39***
	(0.16)	(0.17)	(0.02)	(0.02)

2	-4.44***	-4.22***	-0.39***	-0.36***
	(0.15)	(0.15)	(0.02)	(0.02)
3	-3.42***	-3.23***	-0.31***	-0.28***
	(0.14)	(0.14)	(0.01)	(0.01)
4	-3.22***	-3.04***	-0.32***	-0.30***
	(0.15)	(0.15)	(0.02)	(0.01)
5	-2.82***	-2.65***	-0.26***	-0.23***
	(0.14)	(0.14)	(0.01)	(0.01)
6	-2.48***	-2.34***	-0.23***	-0.21***
	(0.14)	(0.14)	(0.01)	(0.01)
7	-2.49***	-2.37***	-0.24***	-0.22***
	(0.13)	(0.13)	(0.01)	(0.01)
8	-2.53***	-2.40***	-0.23***	-0.21***
	(0.13)	(0.13)	(0.01)	(0.01)
9	-2.06***	-1.90***	-0.22***	-0.20***
	(0.14)	(0.14)	(0.01)	(0.01)
10	-2.08***	-1.94***	-0.19***	-0.16***
	(0.14)	(0.14)	(0.01)	(0.01)
11	-2.46***	-2.07***	-0.22***	-0.18***
	(0.13)	(0.13)	(0.01)	(0.01)
12	-2.03***	-1.92***	-0.18***	-0.17***
	(0.13)	(0.13)	(0.01)	(0.01)
13	-2.09***	-1.89***	-0.19***	-0.17***
	(0.14)	(0.14)	(0.01)	(0.01)
14	-1.73***	-1.54***	-0.15***	-0.13***
	(0.13)	(0.14)	(0.01)	(0.01)
15	-2.12***	-1.93***	-0.18***	-0.16***
	(0.13)	(0.14)	(0.01)	(0.01)
16	-2.00***	-1.86***	-0.17***	-0.15***
	(0.14)	(0.14)	(0.01)	(0.01)
17	-2.00***	-1.81***	-0.17***	-0.15***
	(0.14)	(0.14)	(0.01)	(0.01)
18	-1.71***	-1.56***	-0.13***	-0.11***
	(0.14)	(0.14)	(0.01)	(0.01)
19	-2.12***	-1.99***	-0.16***	-0.14***
	(0.14)	(0.14)	(0.01)	(0.01)
20	-1.94***	-1.81***	-0.15***	-0.14***
	(0.14)	(0.14)	(0.01)	(0.01)
Number of quarter-year workers	826,219	826,219	822,933	822,933
Number of workers	16,322	16,322	16,322	16,322
R-squared	0.091	0.087	0.083	0.078

Notes: Estimates in columns 1 and 3 are based on equation (1) and are graphed in Figure 2. The sample consists of displaced workers and the non-displaced comparison group who were UI claimants at some time during 2002–2014 (see section 2.1 of the text for details). Each regression also controls for a worker-specific fixed effect; a vector of quarterly dummies; worker's age and age squared; a vector of gender, race, and education dummies interacted with the worker's age; logarithm of pre-displacement employer size and 1-digit NAICS code in 2007:IV interacted with a vector of yearly dummies; a simple average of pre-displacement earnings with the primary employer and an average of pre-displacement hours with the primary employer, each interacted with a vector of yearly dummies. Earnings are expressed in constant 2010 dollars.
Standard errors clustered by worker in parentheses (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$).

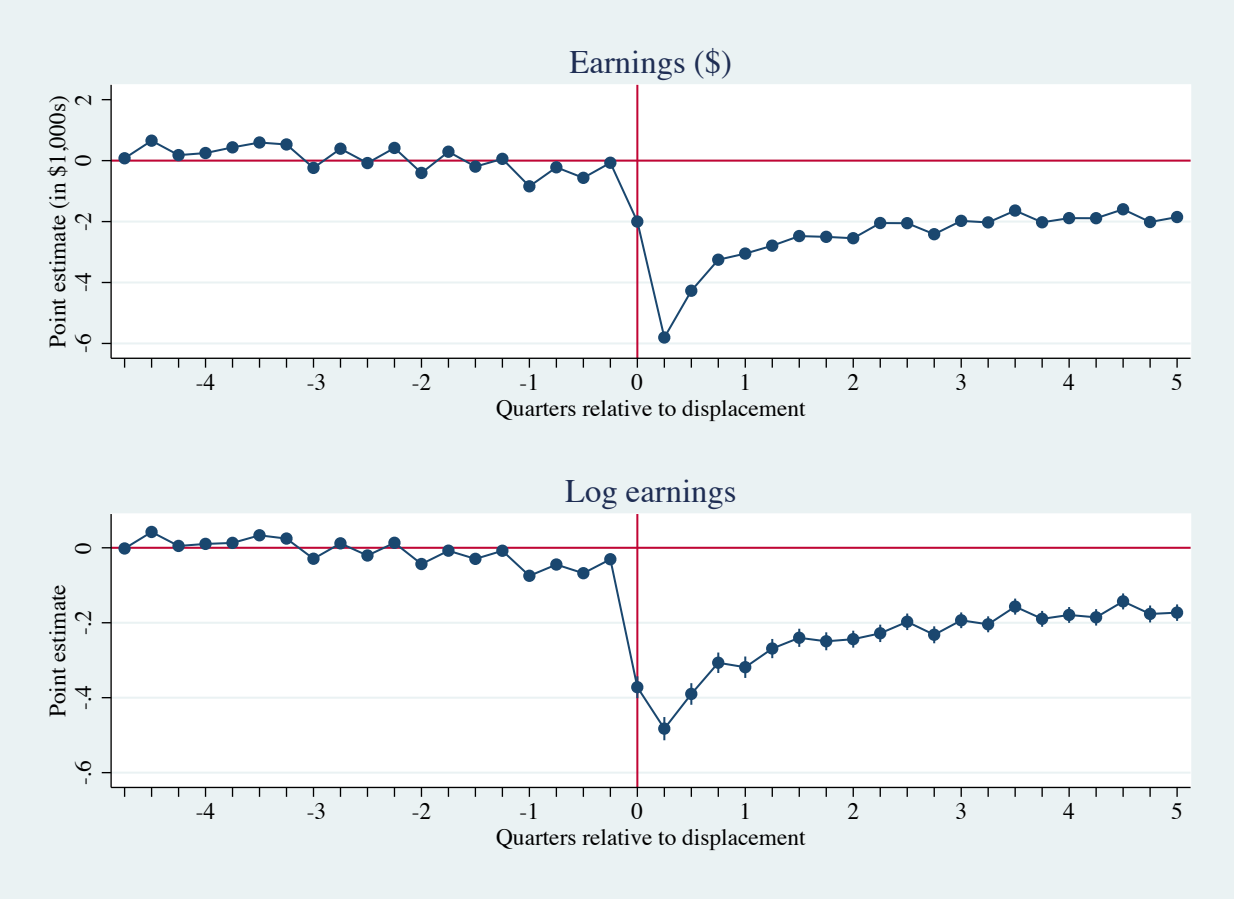
Appendix Table A.2
Estimated effects of displacement on unconditional hours and log hours (from primary employer and all employers)

Outcome variable	Primary hours	All hours	Log primary hours	Log all hours
	(1)	(2)	(3)	(4)
Covariates				
Quarter since displacement				
–20	5.77***	5.55***	0.01	0.01
	(1.59)	(1.68)	(0.00)	(0.00)
–19	-3.81**	-3.75**	-0.01	-0.01
	(1.60)	(1.67)	(0.00)	(0.00)
–18	15.86***	16.63***	0.03***	0.03***
	(1.83)	(1.91)	(0.01)	(0.01)
–17	-0.06	0.47	0.00	0.00
	(1.89)	(1.97)	(0.01)	(0.01)
–16	8.09***	8.65***	0.02***	0.02***
	(1.97)	(2.07)	(0.01)	(0.01)
–15	9.02***	10.13***	0.02***	0.02***
	(1.87)	(1.96)	(0.01)	(0.01)
–14	21.55***	23.08***	0.04***	0.05***
	(1.99)	(2.10)	(0.01)	(0.01)
–13	21.62***	22.39***	0.04***	0.04***
	(2.09)	(2.18)	(0.01)	(0.01)
–12	-1.19	-0.07	-0.01	-0.01
	(2.02)	(2.12)	(0.01)	(0.01)
–11	22.23***	23.74***	0.04***	0.04***
	(2.15)	(2.27)	(0.01)	(0.01)
–10	1.78	2.89	0.00	0.00
	(2.09)	(2.23)	(0.01)	(0.01)
–9	21.68***	23.94***	0.04***	0.04***
	(2.21)	(2.35)	(0.01)	(0.01)
–8	7.81***	10.65***	0.01	0.01**
	(2.19)	(2.35)	(0.01)	(0.01)
–7	6.85***	8.37***	-0.00	-0.00
	(2.28)	(2.41)	(0.01)	(0.01)
–6	-1.14	0.57	-0.01	-0.01
	(2.21)	(2.34)	(0.01)	(0.01)
–5	5.55**	6.39***	0.00	0.00
	(2.30)	(2.42)	(0.01)	(0.01)
–4	-8.60***	-7.18***	-0.03***	-0.03***
	(2.32)	(2.47)	(0.01)	(0.01)
–3	-8.83***	-6.65**	-0.04***	-0.04***
	(2.47)	(2.62)	(0.01)	(0.01)
–2	-15.34***	-13.96***	-0.04***	-0.03***
	(2.28)	(2.41)	(0.01)	(0.01)
–1	-5.09*	-4.11	-0.01	-0.01*
	(2.65)	(2.77)	(0.01)	(0.01)
0	-136.26***	-98.41***	-0.40***	-0.30***
	(3.66)	(3.80)	(0.01)	(0.01)
1	-199.82***	-176.32***	-0.38***	-0.31***
	(4.14)	(4.48)	(0.01)	(0.01)
2	-123.86***	-115.82***	-0.25***	-0.22***
	(4.20)	(4.31)	(0.01)	(0.01)
3	-94.46***	-86.91***	-0.20***	-0.18***
	(4.04)	(4.16)	(0.01)	(0.01)

4	-95.53***	-89.43***	-0.22***	-0.20***
	(3.93)	(4.04)	(0.01)	(0.01)
5	-63.99***	-57.80***	-0.13***	-0.11***
	(3.82)	(3.91)	(0.01)	(0.01)
6	-53.05***	-48.96***	-0.11***	-0.10***
	(3.57)	(3.65)	(0.01)	(0.01)
7	-50.01***	-45.27***	-0.13***	-0.11***
	(3.46)	(3.58)	(0.01)	(0.01)
8	-46.73***	-41.56***	-0.11***	-0.10***
	(3.43)	(3.53)	(0.01)	(0.01)
9	-40.38***	-35.17***	-0.11***	-0.09***
	(3.36)	(3.49)	(0.01)	(0.01)
10	-39.64***	-33.85***	-0.09***	-0.07***
	(3.29)	(3.39)	(0.01)	(0.01)
11	-41.38***	-27.34***	-0.09***	-0.06***
	(3.27)	(3.44)	(0.01)	(0.01)
12	-35.30***	-31.40***	-0.09***	-0.08***
	(3.34)	(3.46)	(0.01)	(0.01)
13	-40.42***	-32.50***	-0.09***	-0.07***
	(3.27)	(3.38)	(0.01)	(0.01)
14	-32.43***	-26.83***	-0.08***	-0.07***
	(3.35)	(3.43)	(0.01)	(0.01)
15	-36.85***	-30.65***	-0.08***	-0.07***
	(3.21)	(3.30)	(0.01)	(0.01)
16	-32.47***	-26.97***	-0.08***	-0.07***
	(3.27)	(3.35)	(0.01)	(0.01)
17	-31.41***	-23.75***	-0.08***	-0.06***
	(3.31)	(3.42)	(0.01)	(0.01)
18	-23.48***	-18.87***	-0.05***	-0.05***
	(3.30)	(3.40)	(0.01)	(0.01)
19	-30.53***	-25.04***	-0.06***	-0.05***
	(3.32)	(3.44)	(0.01)	(0.01)
20	-31.87***	-26.35***	-0.08***	-0.07***
	(3.41)	(3.48)	(0.01)	(0.01)
Number of quarter-year workers	826,219	826,219	819,241	819,500
Number of workers	16,322	16,322	16,322	16,322
R-squared	0.114	0.101	0.054	0.049

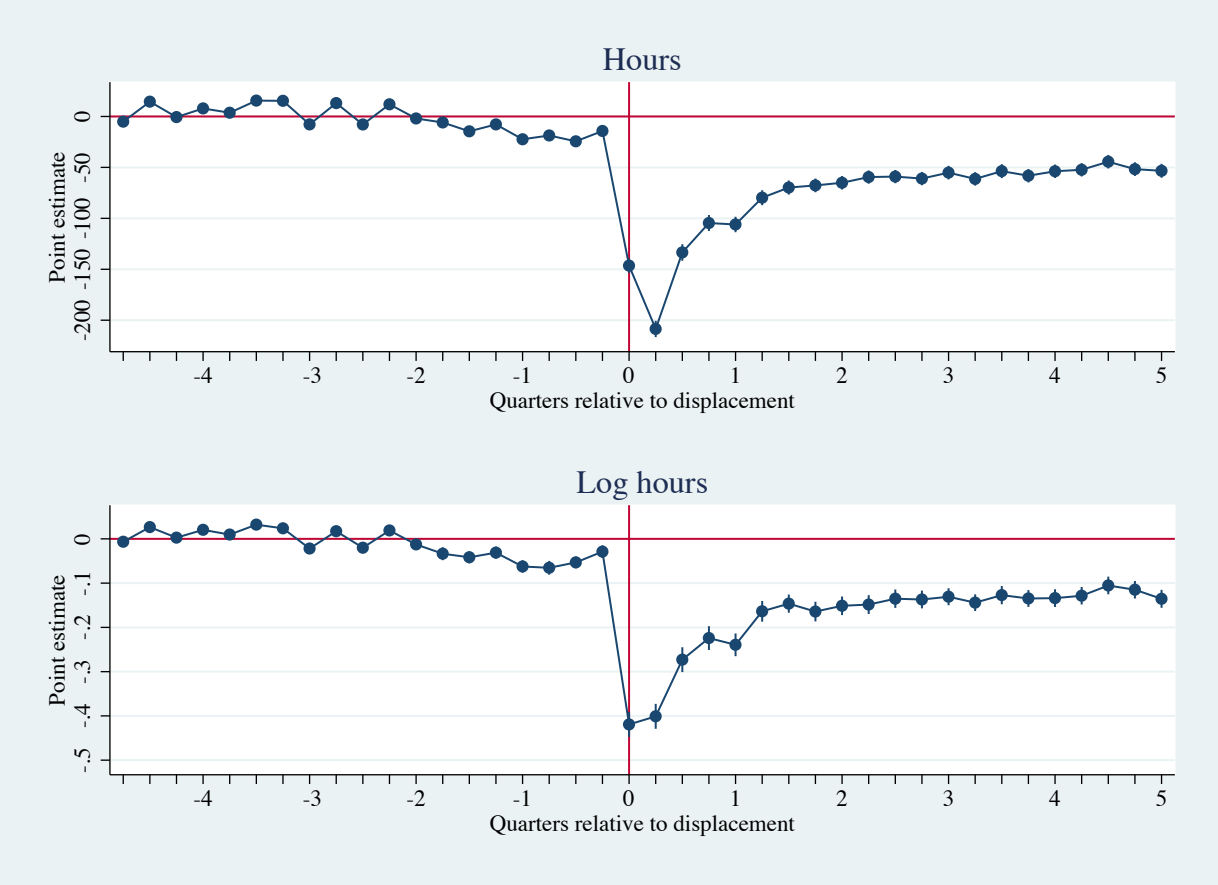
Notes: Estimates in columns 1 and 3 are based on equation (1) and are graphed in Figure 3. The sample consists of displaced workers and the non-displaced comparison group who were UI claimants at some time during 2002–2014 (see section 2.1 of the text for details). Each regression also controls for a worker-specific fixed effect; a vector of quarterly dummies; worker's age and age squared; a vector of gender, race, and education dummies interacted with the worker's age; logarithm of pre-displacement employer size and 1-digit NAICS code in 2007:IV interacted with a vector of yearly dummies; a simple average of pre-displacement earnings with the primary employer and an average of pre-displacement hours with the primary employer, each interacted with a vector of yearly dummies.
Standard errors clustered by workers are in parentheses (*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$).

Appendix Figure A.1
Estimated earnings losses due to displacement, Washington, 2008–2010, based on the random-trend model



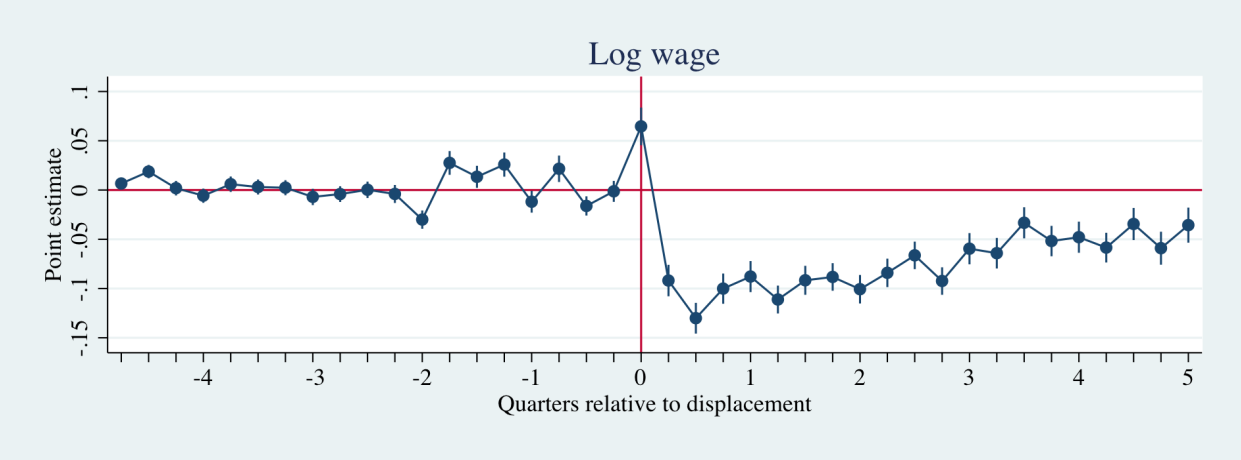
Notes: The top figure shows estimated δ_ks—quarterly unconditional earnings lost due to displacement (in constant 2010 $1,000s)—based on the random trend model (equation (2)) with unconditional earnings from the primary employer as the dependent variable. The bottom figure shows estimated δ_ks—logarithm of quarterly earnings lost due to displacement—based on equation (2) with the log of earnings from the primary employer as the dependent variable. Whiskers (which are very small) denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1, 4.1, and 4.2 of the text for details.

Appendix Figure A.2
Estimated work hour losses due to displacement, Washington, 2008–2010, based on the random-trend model



Notes: The top figure shows estimated δ_ks—quarterly unconditional hours lost due to displacement—based on the random trend model (equation (2)) with unconditional hours at the primary employer as the dependent variable. The bottom figure shows estimated δ_ks—logarithm of quarterly hours lost due to displacement—based on equation (2) with the log of hours at the primary employer as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1, 4.1, and 4.2 of the text for details.

Appendix Figure A.3
Estimated hourly wage rate losses due to displacement, Washington, 2008–2010, based on the random-trend model

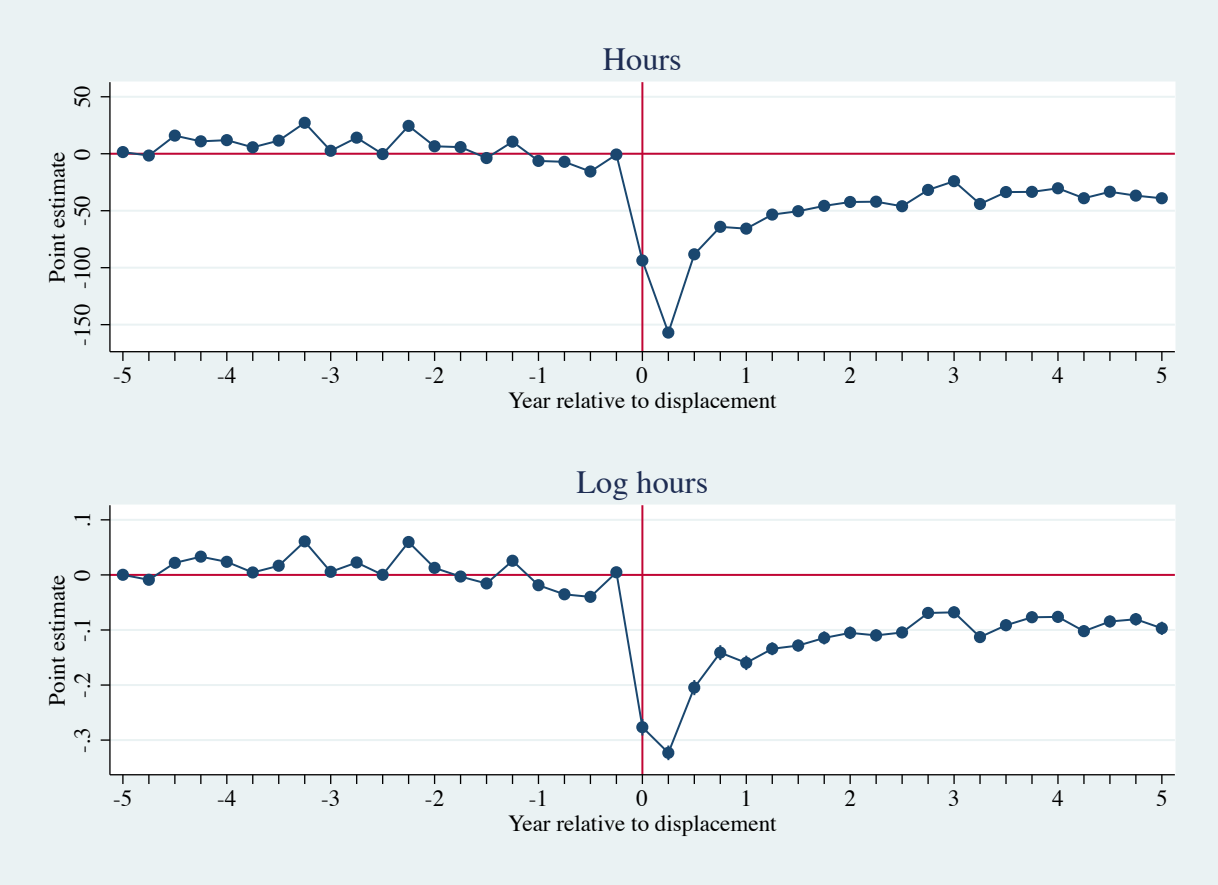


Notes: The figure shows estimated δ_ks—the reduction in the log hourly wage rate due to displacement—based on the random trend model (equation (2)) with the log of the hourly wage rate at the primary employer (constant 2010 dollars per hour) as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.1, 4.1, and 4.2 of the text for details.

Appendix Figure A.4
Estimated earnings losses due to displacement, based on the broadened sample of displaced and non-displaced workers, Washington, 2008–2010

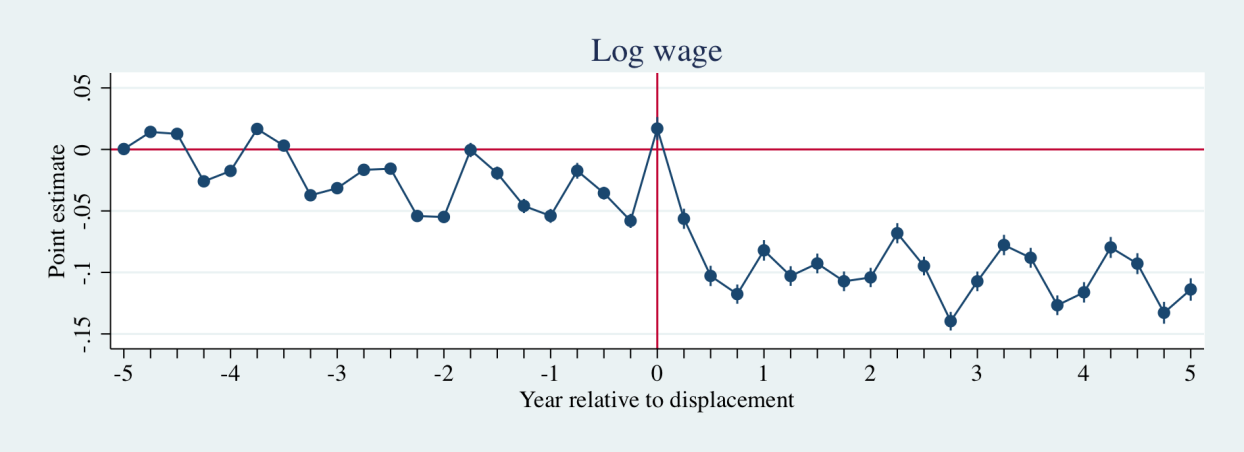
Notes: The figures show earnings losses estimated using the broadened sample of displaced and non-displaced workers—that is, without restricting the sample to workers who claimed UI at some time during 2002–2014—see the discussion in section 2.1. (For estimates using the UI claimant sample, see Figure 2 in the main text.) The top figure shows estimated δ_ks—quarterly unconditional earnings lost due to displacement (in constant 2010 $1,000s)—based on equation (1) with unconditional earnings from the primary employer as the dependent variable. The bottom figure shows estimated δ_ks—logarithm of quarterly earnings lost due to displacement—based on equation (1) with the log of earnings from the primary employer as the dependent variable. Whiskers (which are very small) denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See section 2.1 of the text for details of the broadened and UI claimant samples.

Appendix Figure A.5
Estimated work hour losses due to displacement, based on the broadened sample of displaced and non-displaced workers, Washington, 2008–2010



Notes: The figures show quarterly work hour losses estimated using the broadened sample of displaced and non-displaced workers—that is, without restricting the sample to workers who claimed UI at some time during 2002–2014—see the discussion in section 2.1. (For estimates using the UI claimant sample, see Figure 3 in the main text.) The top figure shows estimated δ_ks—quarterly unconditional hours lost due to displacement—based on equation (1) with unconditional hours at the primary employer as the dependent variable. The bottom figure shows estimated δ_ks—logarithm of quarterly hours lost due to displacement—based on equation (1) with the log of hours at the primary employer as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See section 2.1 of the text for details of the broadened and UI claimant samples.

Appendix Figure A.6
Estimated hourly wage rate losses due to displacement, based on the broadened sample of displaced and non-displaced workers, Washington, 2008–2010



Notes: The figure shows hourly wage rate losses estimated using the broadened sample of displaced and non-displaced workers—that is, without restricting the sample to workers who claimed UI at some time during 2002–2014—see the discussion in section 2.1. (For estimates using the UI claimant sample, see Figure 4 in the main text.) The figure plots estimated δ_ks—the reduction in the log hourly wage rate due to displacement—based on equation (1) with the log of the hourly wage rate at the primary employer (constant 2010 dollars per hour) as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See section 2.1 of the text for details of the broadened and UI claimant samples.

Appendix B: Estimation of employer fixed effects for earnings, hours, and wage rates

B.1 Construction of the analysis sample

The raw data for the AKM analysis come from quarterly administrative wage records of Washington State for calendar years 2002–2014. These quarterly reports are submitted by all UI–covered employers for the purposes of administering UI benefit claims and payroll taxes. A record appears for each employer–worker–quarter combination, and each record includes a year–quarter indicator; the ID and NAICS industry code of the reporting employer; and the worker ID, earnings, and work hours of the worker with that employer in the specified quarter. The availability of quarterly hours for each employer allows us to include both full–time and part–time workers (and jobs) in the analysis. A worker has as many wage records as he or she has employers in a given quarter.

From these raw data, we construct a linked employer-employee panel for analysis following a procedure developed by Sorkin (2016). We first select each worker's primary employer for each quarter. In most cases, a worker has only one employer during the quarter, but for about 27 percent of the worker–quarter observations, we need to define the worker's primary employer as the employer from whom the worker earned the largest share of his/her earnings in that quarter.

We next define an employment spell as a series of at least five consecutive quarters during which a worker has earnings from the same primary employer. For each of these spells, we drop the first quarter (so as to avoid making inferences about earnings and hours based on a partial quarter of employment) and the last two quarters (to avoid making inferences based on earnings and hours in the quarter before a job loss and the quarter of a job loss).

We then annualize the remaining quarterly data within each calendar year, conditional on the calendar year including at least two consecutive quarters of earnings from the same primary

employer. Earnings are defined as annualized earnings in a given year with the principal employer, and similarly for hours and wage rates. Figure B.1 illustrates the process and gives some examples, described in the figure notes. Ultimately, the unit of observation is the worker–year, with a focus on the primary employer in a year.[1]

Finally, we impose several restrictions on the sample, dropping the following:

- workers with more than 9 employers in a year (this affects 1 percent of the sample)
- workers with annual earnings less than $2,850 (in 2005 dollars) and workers with calculated hourly wage rates ≤ $2.00/hour (in 2005 dollars) (Sorkin 2016; Card, Heining, and Kline 2013)
- workers who worked fewer than 400 hours in the year[2]
- workers who worked more than 4,800 hours in the year
- employers with fewer than 5 employees in the year (Song et al. 2015)
- all displaced workers and all non-displaced comparison workers (as defined in section 2.1)

We impose the last restriction so that observations used in the displaced worker analysis are not used to estimate employer fixed effects. Including these workers could create a mechanical relationship between the employer fixed effects and displaced workers' earnings, hours, and wage rate losses, potentially overstating the role of employer fixed effects.

In the administrative wage records, the employer is the entity from which the state collects UI payroll taxes and to which the state "charges" UI benefits (for the purpose of experience rating the UI payroll tax). Typically, the employer is the set of establishments operating in

[1] By removing the first quarter and the last two quarters of any worker–primary employer spell and by including at least two consecutive quarters of earnings from the same primary employer in a calendar year, we lose about 27 percent of all worker–primary employer spells (that are shorter than five consecutive quarters). If we only remove the first quarter and the last two quarters of any worker–primary employer spell (without requiring at least two consecutive quarters of earnings from the same primary employer in a calendar year), we lose about 23 percent of all worker–primary employer spells.

[2] In Washington, 680 paid hours in approximately the previous year are required for UI eligibility.

Washington under a single owner, so for a company operating entirely in Washington (with a single or multiple addresses) the employer is a firm, and for a company with one address in Washington, the employer is also an establishment.

The first column of Table B.1 ("Full annualized panel") shows summary statistics for the annualized linked employer-employee panel—that is, after processing the quarterly records as illustrated in Figure B.1 and imposing the sample restrictions described above. The second column of Table B.1 shows the number of observations in the largest connected set, which we used to estimate the AKM model (see section 3.2 of the main text). Identification of employer fixed effects comes from workers moving between primary employers, so it is important to know how much mobility there is in the sample. Table B.1 shows that there are about 3.5 million unique workers in the largest connected set, and about a third of those workers change primary employer at least once during 2002–2014.

B.2 Employer births and deaths

An employer ID may disappear if the employer becomes inactive or is acquired by or merges with another employer. In the case of a merger or acquisition, the employer's ID will change—it will appear that one employer has "died" and another has been "born." We cannot distinguish between the reorganization and the closing of an employer, but like Card, Heining, and Kline (2013), we take the view that reorganization may imply new employment policies, so it makes sense to treat reorganization as creation of a new entity and to estimate a separate (new) employer fixed effect. As Card, Heining, and Kline (2013) point out, treating assignment of a new ID to an existing employer leads to a loss of efficiency but no bias. That is, if the employer effect on wages does not change, we are estimating the same fixed effect twice, rather than once.

B.3 Estimation and variance decompositions

We estimate the AKM model (equation 3 in the main text) using the linked employer-employer panel for each of the three outcomes: log earnings, log hours worked, and log wage rates, as defined earlier. Table B.2 displays the resulting variance decompositions. The variance of each outcome is decomposed five components: one due to worker effects, one due to employer effects, one due to year effects, one due to the covariance between worker and employer effects (sorting of workers and employers), and a residual. (To conserve space, we do not show the worker-year or employer-year covariances. Together, these two covariances explain about one percent of the variation in each outcome.) The numbers in italics below each variance–covariance term show the share of the total variance of each outcome attributable to that component.

Table B.2 shows that worker fixed effects explain a large share of the variation in all three outcomes: 52 percent of the variation in earnings, 45 percent of the variation in work hours, and 60 percent of the variation in hourly wage rates. This compares with worker fixed effects explaining 55 percent of the variation in earnings in Sorkin (2016) (see his Table 1.1, U.S., 2000–2008) and 51–61 percent of daily earnings in Card, Heining, and Kline (Table 3, Germany, 1985–2009).

Nevertheless, employer effects are also important. Table B.2 shows that employer fixed effects explain about 20 percent of the variation in earnings, 35 percent of the variation in work hours, and 13 percent of the variation in hourly wage rates. This compares with employer fixed effects explaining about 22 percent of the variation in earnings in Sorkin (2016) and 18–21 percent in CHK (Table 3, Germany, 1985–2009).

Table B.2 also shows that match effects—estimated from a model that regresses each outcome variable on worker–employer spell indicators and year effects—appear to be only moderately important. The adjusted–R^2 from the AKM model for earnings equals about 0.87 [similar to Sorkin (2016), who obtains an adjusted–R^2 of 0.85], whereas the adjusted–R^2 from a model for earnings that has a match component equals about 0.93. Although the fit is better for the match effects model, the difference between the AKM and match–effects models is not dramatic.

B.4 Event studies of inter–employer mobility

Following Card, Heining, and Kline (2013), we conduct event studies of how earnings, work hours, and wage rates change when workers move between employers. The purpose of these event studies is to infer the importance of employers in determining earnings, hours, and wage rates, holding constant worker fixed effects. For example, we can follow a group of workers who start with an employer whose fixed effect (ψ) is in the fourth quartile, and who then move to other employers. Some of these "destination" employers will have a high ψ, whereas others will have a low ψ, and observing how workers' earnings, hours, and wage rates change with these moves will provide information about employers' influence on earnings, hours, and wage rates.

The procedure for constructing these event studies is as follows. For a given outcome (earnings, hours, or wage rates) we classify employers into quartiles by their AKM–estimated employer fixed effect (ψ). Next, for a given year t, we select workers in each employer quartile who have been with the employer at least two years, change employers (i.e., are observed with a different employer in year t+1), and remain with the subsequent employer for at least two years.

Finally, we calculate the average outcome before and after the move for each possible type of move (Q1→Q1, Q1→Q2, ..., Q4→Q3, Q4→Q4).

Figure B.2 shows the results for eight of the transitions (Q4→Q4, Q4→Q3, Q4→Q3, Q4→Q1 Q1→Q4, Q1→Q3, Q1→Q2, Q1→Q1) for log earnings. Figures B.3 and B.4 show same transitions for log work hours and log wage rates. (Table B.3 displays the data underlying these figures.)

Several points are worth noting in Figure B.2. First, workers who start with a low-ψ (Q1) employer and move to a high-ψ (Q4) employer experience a 70 log point increase in their earnings (and smaller effects for moves to other higher-ψ employers). This change is 60 log points if adjusted by within-quartile change (see the "Adjusted change from year –2 to year 1" column in Table B.3.) Conversely, workers who start with a high-ψ (Q4) employer and move to a low-ψ (Q1) employer experience a 54 log point decrease in their earnings (and smaller effects for moves to other lower-ψ employers). This change is 63 log points if adjusted by within-quartile change. In short, employers matter in determining earnings—upwardly mobile workers improve their earnings conditional on their initial quartile, and downwardly mobile workers have worse earnings conditional on their initial quartile. This tends to support the premise of the AKM approach.

Second, the pattern of movement suggests sorting of lower-α workers to lower-ψ employers and of higher-α workers to higher-ψ employers. For example, before the move, workers with the highest-ψ employers are stratified by the type of employer to which they move—those who move to other high-ψ employers have the higher pre–move earnings than moving to lower-ψ employers.

Third, the average worker who moves from one Q1 employer to another Q1 employer experiences no earnings change; and similarly for workers who move Q4→Q4, Q2→Q2, and Q3→Q3. The implication is that idiosyncratic matches are not of great importance; if they were, Q1 workers would be observed moving strategically to other Q1 employers—that is, moving to other Q1 employers and increasing their earnings as a result—and similarly for Q2→Q2, Q3→Q3, and Q4→Q4 moves. Such within-quartile transitions provide a kind of counterfactual: workers who do not move have the same α and ψ, so we would expect their profiles of earnings, work hours, and wage rates to be essentially flat. Figure B.1 suggests this is the case.

Fourth, the approximate symmetry of changes suggests that workers do not necessarily change jobs in order to obtain a pecuniary return. Rather, they may be moving to obtain some non–pecuniary benefit or compensating differential (Sorkin 2016). Fifth, all three outcome variables show slight pre- and post-transition trends, although the trends do not vary by quartile group.

Appendix Table B.1

Summary statistics for the full annualized panel and the largest connected set (AKM analysis sample)

Full Sample	Full annualized panel	Largest connected set
Number of worker–year observations	25,578,007	22,941,274
Number of workers	4,450,785	3,508,811
Number of employers	341,553	218,593
Number of movers	1,546,094	1,463,030
Log earnings (mean)	10.321	10.432
Log hours (mean)	7.338	7.453
Log hourly wage rate (mean)	3.063	3.052

Source: Authors' tabulations of Washington administrative wage records, 2002–2014.

Appendix Table B.2
Variance decomposition of log earnings, log hours, and log hourly wage rates, Washington, 20022014
(variance shares accounted for by each component in italics)

	Variance of outcome and decomposition into components						AKM model fit		Match effects model fit	
Outcome	Total variance	Worker FEs (α)	Employer FEs (ψ)	Year FEs (θ)	2cov(α,ψ)	Residual	Adj. R^2	RMSE	Adj. R^2	RMSE
Log earnings	0.596	0.309	0.123	0.004	0.101	0.064	0.872	0.253	0.925	0.211
		0.519	*0.207*	*0.006*	*0.169*	*0.107*				
Log hours	0.129	0.058	0.045	0.000	-0.013	0.039	0.638	0.197	0.754	0.178
		0.449	*0.352*	*0.001*	*-0.104*	*0.303*				
Log hourly wage rate	0.411	0.247	0.053	0.022	0.065	0.040	0.885	0.199	0.932	0.167
		0.601	*0.128*	*0.054*	*0.159*	*0.096*				

Source: Authors' tabulations of Washington administrative wage records, 2002–2014
Notes: The universe consists of workers in the AKM dataset. The decompositions include covariances between worker and employer fixed effects and year fixed effects. Because these covariances explain only about 1 percent of the variation, they are omitted from the table. The match effects model is estimated by regressing each outcome variable on worker–employer indicators and year indicators.

Appendix Table B.3
Mean outcomes, classified by quartile of employer fixed effect

Panel A: Mean log earnings of movers, classified by quartile of employer earnings fixed effect at origin (year = –1) and destination (year = 0) employer

Origin/destination quartile	Year –2	Year –1	Year 0	Year 1	Change from year –2 to year 1	Adjusted change from year –2 to year 1[a]	Number of observations
1 to 1	9.79	9.79	9.88	9.89	0.10	0.00	247,950
1 to 2	9.83	9.83	10.12	10.14	0.31	0.21	120,636
1 to 3	9.80	9.81	10.27	10.30	0.50	0.40	74,936
1 to 4	9.88	9.89	10.54	10.58	0.70	0.60	38,488
2 to 1	10.16	10.13	10.03	10.03	-0.12	-0.18	80,566
2 to 2	10.29	10.28	10.35	10.35	0.06	0.00	173,078
2 to 3	10.36	10.35	10.54	10.55	0.19	0.13	116,916
2 to 4	10.39	10.39	10.75	10.78	0.38	0.33	57,176
3 to 1	10.36	10.32	10.02	10.02	-0.34	-0.40	29,168
3 to 2	10.52	10.50	10.46	10.46	-0.07	-0.12	84,368
3 to 3	10.65	10.64	10.70	10.71	0.06	0.00	234,702
3 to 4	10.73	10.73	10.92	10.94	0.21	0.15	122,092
4 to 1	10.72	10.70	10.18	10.18	-0.54	-0.63	13,102
4 to 2	10.77	10.74	10.51	10.51	-0.25	-0.34	27,982
4 to 3	10.87	10.86	10.81	10.81	-0.06	-0.15	84,974
4 to 4	11.15	11.15	11.21	11.24	0.09	0.00	313,108
							1,819,242

Notes: a. Adjusted change is the change from year –2 to year 1, minus the within-quartile change from year –2 to year 1.

Panel B: Mean log hours of movers, classified by quartile of employer hours fixed effect at origin (year = –1) and destination (year = 0) employer

Origin/destination quartile	Year –2	Year –1	Year 0	Year 1	Change from year –2 to year 1	Adjusted change from year –2 to year 1[a]	Number of observations
1 to 1	7.24	7.22	7.27	7.26	0.02	0.00	221,266
1 to 2	7.27	7.24	7.49	7.47	0.20	0.18	124,596
1 to 3	7.22	7.18	7.56	7.55	0.33	0.32	69,170
1 to 4	7.21	7.17	7.65	7.64	0.43	0.42	55,296
2 to 1	7.45	7.41	7.29	7.28	-0.18	-0.17	78,030
2 to 2	7.51	7.48	7.52	7.50	-0.01	0.00	169,094
2 to 3	7.50	7.47	7.58	7.57	0.07	0.08	142,100
2 to 4	7.49	7.46	7.66	7.65	0.16	0.16	83,628
3 to 1	7.54	7.50	7.25	7.23	-0.31	-0.31	32,736
3 to 2	7.57	7.54	7.51	7.49	-0.09	-0.08	90,480
3 to 3	7.58	7.55	7.58	7.57	-0.01	0.00	189,088
3 to 4	7.59	7.57	7.66	7.65	0.05	0.06	144,280
4 to 1	7.65	7.61	7.21	7.20	-0.45	-0.44	21,302
4 to 2	7.66	7.63	7.50	7.48	-0.18	-0.17	47,296
4 to 3	7.65	7.63	7.60	7.58	-0.07	-0.07	115,634
4 to 4	7.67	7.66	7.68	7.67	0.00	0.00	235,246
							1,819,242

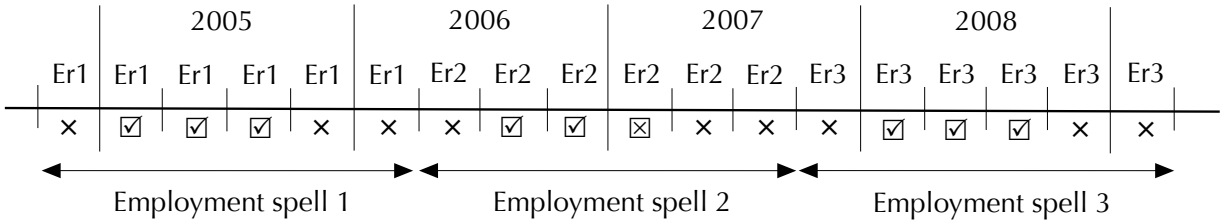
Notes: a. Adjusted change is the change from year –2 to year 1, minus the within-quartile change from year –2 to year 1.

Panel C: Mean log hourly wage rate of movers, classified by quartile of employer wage fixed effect at origin (year = –1) and destination (year = 0) employer

Origin/destination quartile	Year –2	Year –1	Year 0	Year 1	Change from year –2 to year 1	Adjusted change from year –2 to year 1[a]	Number of observations
1 to 1	2.46	2.49	2.53	2.57	0.12	0.00	225,660
1 to 2	2.54	2.59	2.75	2.80	0.26	0.15	121,060
1 to 3	2.57	2.64	2.90	2.96	0.39	0.27	82,656
1 to 4	2.65	2.71	3.17	3.23	0.59	0.47	45,184
2 to 1	2.72	2.76	2.69	2.73	0.01	-0.12	97,952
2 to 2	2.86	2.90	2.95	2.99	0.13	0.00	164,396
2 to 3	2.91	2.96	3.09	3.14	0.23	0.10	127,162
2 to 4	2.93	2.98	3.27	3.33	0.40	0.27	61,112
3 to 1	2.91	2.94	2.75	2.79	-0.13	-0.27	44,052
3 to 2	3.03	3.07	3.04	3.07	0.04	-0.10	100,114
3 to 3	3.12	3.17	3.22	3.27	0.14	0.00	195,376
3 to 4	3.22	3.27	3.45	3.50	0.29	0.14	121,480
4 to 1	3.17	3.21	2.78	2.82	-0.35	-0.51	17,238
4 to 2	3.29	3.33	3.12	3.16	-0.14	-0.30	40,524
4 to 3	3.37	3.41	3.33	3.37	0.00	-0.16	95,154
4 to 4	3.59	3.64	3.68	3.75	0.16	0.00	280,122
							1,819,242

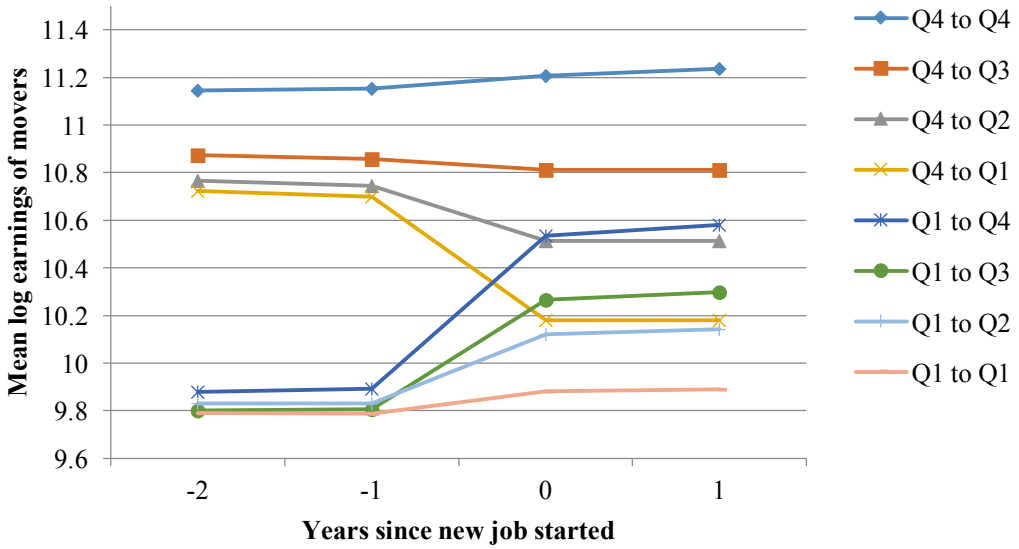
Notes: a. Adjusted change is the change from year –2 to year 1, minus the within-quartile change from year –2 to year 1.

Appendix Figure B.1
Construction of the analysis sample for the AKM dataset

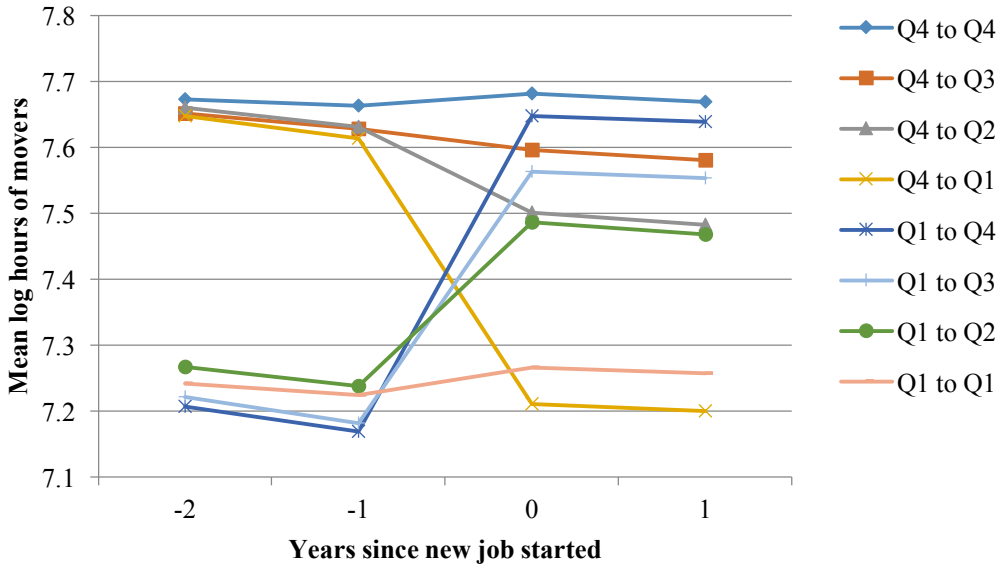


Notes: The figure shows three hypothetical employment spells with three different employers (Er1, Er2, and Er3), each of which has the minimum five quarters required to be included in the analysis sample. The first quarter and last two quarters of each employment spell (denoted by ×) are dropped from the analysis, and outcomes from the remaining quarters are then annualized for each calendar year, conditional on the calendar year including at least two consecutive quarters of earnings from the same primary employer. For example, outcomes for 2005 (Employment spell 1) and 2008 (Employment spell 3) are obtained by averaging the outcomes for the first, second, and third quarters of 2005 (or 2008) and multiplying by four. (The quarters used in the calculations are denoted by ☑.) Outcomes for 2006 (Employment spell 2) are obtained by averaging the outcomes for the third and fourth quarters of 2006 and multiplying by four. Outcomes for 2007 (part of Employment spell 2) are excluded because 2007 does not include two consecutive quarters that can be used under the selection criteria (that is, after excluding the first quarter and last two quarters of each employment spell). As a result, the data from 2007:I (denoted by ☒) are not used.

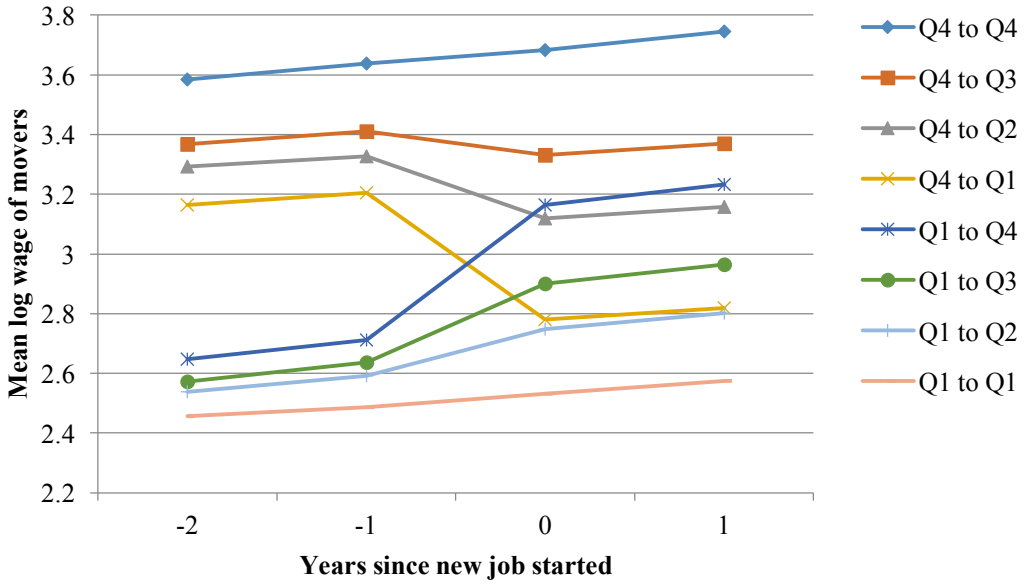
Appendix Figure B.2
Mean log earnings of movers, classified by quartile of AKM employer earnings effects (ψ) at origin (year = –1) and destination (year = 0) employer



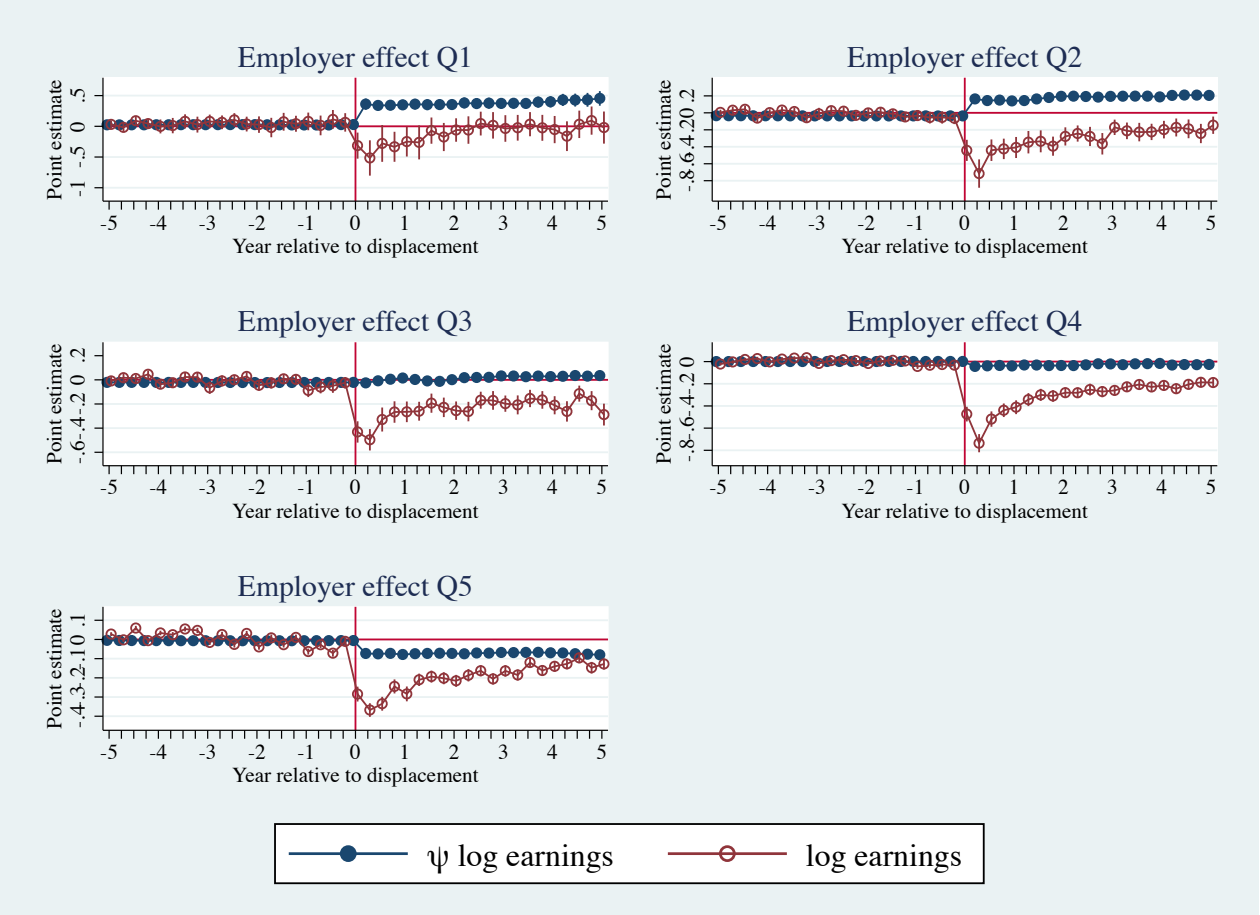
Appendix Figure B.3
Mean log hours of movers, classified by quartile of AKM employer hours effects (ψ) at origin (year = –1) and destination (year = 0) employer



Appendix Figure B.4
Mean log hourly wage rates of movers, classified by quartile of AKM employer wage rate effects (ψ) at origin (year = –1) and destination (year = 0) employer



Appendix Figure B.5
Estimated log earnings losses due to displacement, and displacement losses due to foregone employer fixed effects, by quintile of pre-displacement employer fixed effect for log earnings

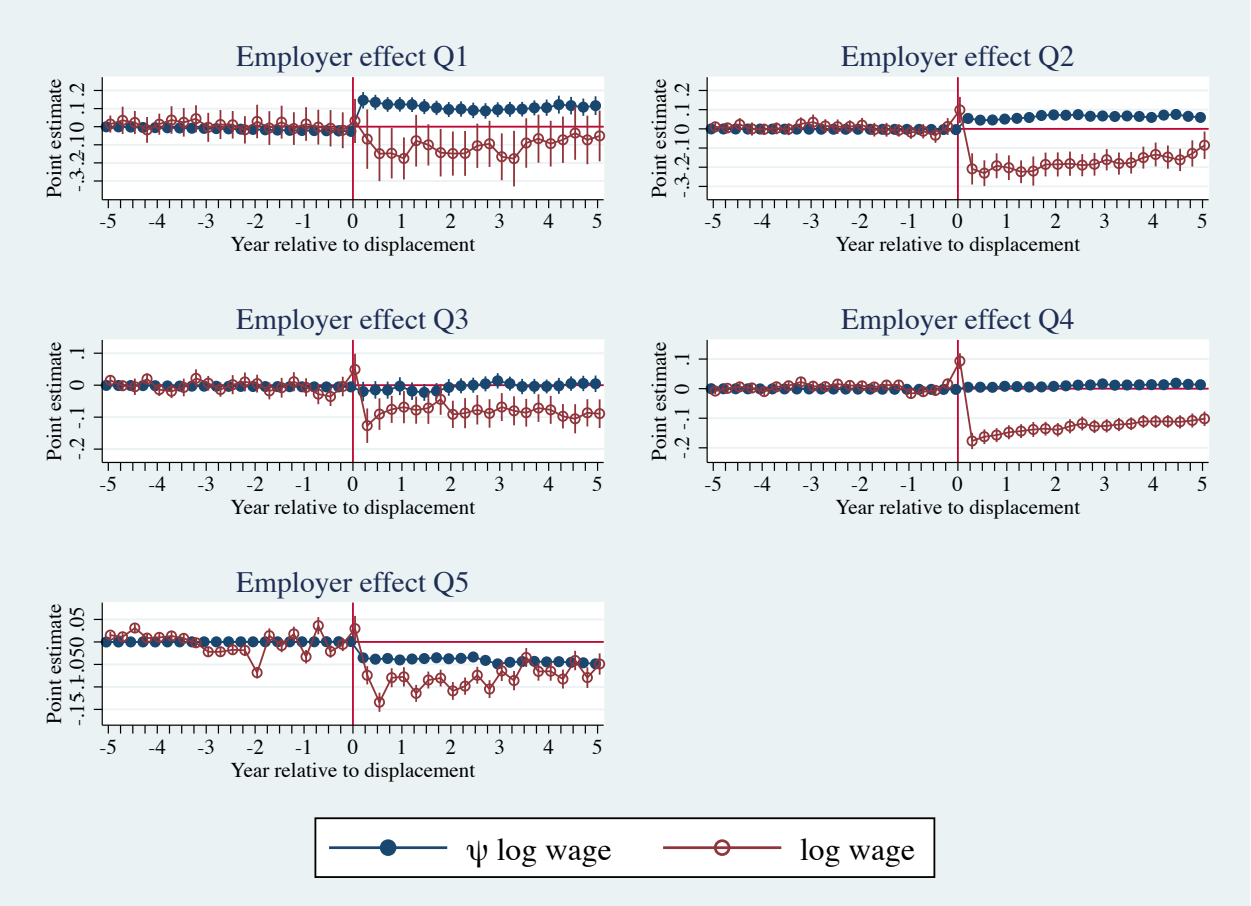


Notes: The figures show estimated full earnings losses due to displacement (red circles, estimated from equation (1)) compared with displacement losses attributable to foregone employer fixed effects (blue dots, estimated from equation (4)), for workers displaced from employers grouped by quintile of their employer fixed effect for earnings. (The figure for "Employer effect Q5" is repeated from Figure 9 in the main text.) Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.2 and 5.2 of the text for details.

Appendix Figure B.6
Estimated log work hour losses due to displacement, and displacement losses due to foregone employer fixed effects, by pre-displacement employer fixed effect for log earnings

Notes: The figures show estimated full work hour losses due to displacement (red circles, estimated from equation (1)) compared with displacement losses attributable to foregone employer fixed effects (blue dots, estimated from equation (4)), for workers displaced from employers grouped by quintile of their employer fixed effect for earnings. (The figure for "Employer effect Q5" is repeated from Figure 9 in the main text.) Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.2 and 5.2 of the text for details.

Appendix Figure B.7
Estimated log hourly wage rate losses due to displacement, and displacement losses due to foregone employer fixed effects, by pre-displacement employer fixed effect for log earnings



Notes: The figures show estimated full hourly wage rate losses due to displacement (red circles, estimated from equation (1)) compared with displacement losses attributable to foregone employer fixed effects (blue dots, estimated from equation (4)), for workers displaced from employers grouped by quintile of their employer fixed effect for earnings. (The figure for "Employer effect Q5" is repeated from Figure 9 in the main text.) Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 3.2 and 5.2 of the text for details.

Appendix C: Estimates using an alternative comparison group

The comparison group used by JLS included only workers continuously employed with their primary employer throughout the observation window (in our case, 2002–2014). As Krolikowski (2018) has pointed out, this amounts to conditioning on an outcome (employment throughout the post-displacement period), and it can be expected to lead to an overstatement of the losses of displaced workers. Accordingly, we estimate equation (1) using a different comparison group, specifically, long-tenure workers (that is, employed by the same primary employer during 2002–2007) who continued with the same employer (that is, were not displaced) during 2008–2010, but who may have changed employers or separated from the primary employer sometime after 2010. This comparison group is no longer selected on a positive outcome—continuous employment in the post-displacement period—so it is less likely than the JLS comparison group to exaggerate the long-term losses resulting from displacement. We interpret the estimates obtained using this alternative comparison group as a lower bound of the effects of displacement.

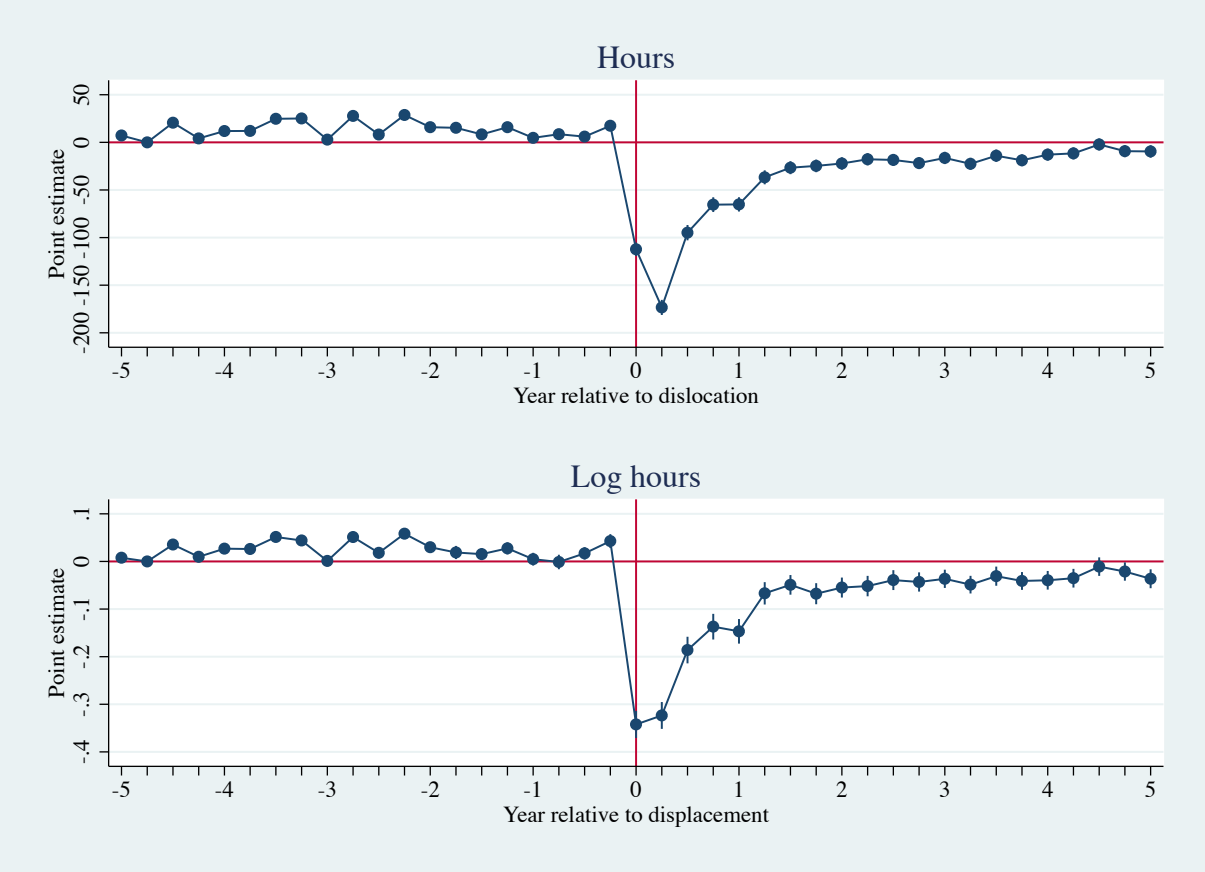
Figures C.1–C.3 show the results of estimating equation (1) for earnings, hours, and hourly wage rates, using this alternative comparison group. In the quarter after displacement, earnings drop by 41 log points (compared with 49 log point using the baseline comparison group), hours drop by 32 log points (compared with 38 log points using the baseline comparison group), and wage rates are lower by 9 log points (compared with 11 log points using the baseline comparison group). After five years, earnings are lower than the alternative comparison group's by 8 log points (compared with 15 log points using the baseline comparison group), hours are lower by 4 log points (compared with 7 log points using the baseline comparison group), and hourly wage rates are lower by 4 log points (compared with 8 log points using the baseline

comparison group). Hence, using the alternative comparison group suggests long-term losses that are just under half those estimated using the baseline comparison group.

Appendix Figure C.1
Earnings losses due to displacement estimated using the alternative comparison group

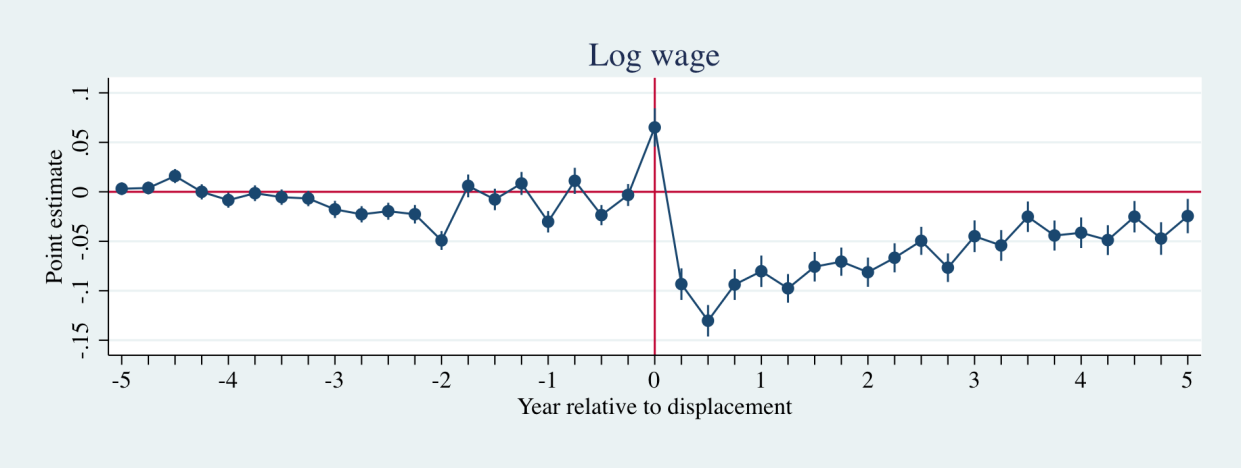
Notes: The figures show earnings losses estimated using the comparison group of non-displaced workers suggested by Krolikowski (2018)—see the discussion above. (For estimates using the baseline comparison group, see Figure 2 in the main text.) The top figure shows estimated δ_ks—quarterly unconditional earnings lost due to displacement (in constant 2010 $1,000s)—based on equation (1) with unconditional earnings from the primary employer as the dependent variable. The bottom figure shows estimated δ_ks—logarithm of quarterly earnings lost due to displacement—based on equation (1) with the log of earnings from the primary employer as the dependent variable. Whiskers (which are very small) denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 2.1 and the above discussion for details of the comparison groups.

Appendix Figure C.2
Work hour losses due to displacement estimated using the alternative comparison group



Notes: The figures show quarterly work hour losses estimated using the comparison group of non-displaced workers suggested by Krolikowski (2018)—see the discussion above. (For estimates using the baseline comparison group, see Figure 3 in the main text.) The top figure shows estimated δ_ks—quarterly unconditional hours lost due to displacement—based on equation (1) with unconditional hours from the primary employer as the dependent variable. The bottom figure shows estimated δ_ks—logarithm of quarterly hours lost due to displacement—based on equation (1) with the log of hours from the primary employer as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 2.1 and the above discussion for details of the comparison groups.

Appendix Figure C.3
Hourly wage rate losses due to displacement estimated using the alternative comparison group



Notes: The figure show hourly wage rate losses estimated using the comparison group of non-displaced workers suggested by Krolikowski (2018)—see the discussion above. (For estimates using the baseline comparison group, see Figure 4 in the main text.) The figure plots estimated δ_ks—the reduction in the log hourly wage rate due to displacement—based on equation (1) with the log of the hourly wage rate at the primary employer (constant 2010 dollars per hour) as the dependent variable. Whiskers denote 95-percent confidence intervals based on standard errors clustered by worker. The vertical lines denote the quarter of displacement.
Source: Authors' calculations using Washington administrative wage and claims records. See sections 2.1 and the above discussion for details of the comparison groups.